HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OP PLAN REVISED	FY 2001 OP PLAN REVISED	FY 2002* PRES BUDGET	Page Number
	(Thousands of Dollars)			
Vehicle	950,100	716,926		HSF 1-5
Operations Capability	703,600	824,682		HSF 1-16
[Construction of Facilities included]	[56]	[--]		
Research	394,400	457,391		HSF 1-24
[Construction of Facilities included]	[3,000]	[--]		
Russian Program Assurance	200,000	24,040		HSF 1-45
[Construction of Facilities included]	[1,000]	[--]		
Crew Return Vehicle	75,000	89,802		HSF 1-47
Total	2,323,100	2,112,841	2,087,400	

Distribution of Program Amount by Installation			(Preliminary)
Johnson Space Center	1,681,300	1,502,542	1,650,500
Kennedy Space Center	123,600	109,648	109,300
Marshall Space Flight Center	390,100	309,927	196,200
Ames Research Center	55,500	72,647	52,000
Langley Research Center	2,500	3,995	100
Glenn Research Center	52,000	73,705	54,500
Goddard Space Flight Center	700	3,375	2,700
Dryden Flight Research Center	2,600	6,135	
Jet Propulsion Laboratory	9,800	13,500	2,000
Headquarters	5,000	17,367	20,100
Total	2,323,100	2,112,841	2,087,400

* FY 2002 funding is currently under review and allocations to Vehicle, Operations, Research, RPA, CRV and final center distributions will be determined as part of program assessments. Any reserves identified as part of the assessments will be managed and dispositioned by the Office of Space Flight headquarters management team.

PROGRAM GOALS

The goal of the International Space Station (ISS) is to establish a long-duration habitable residence and laboratory for science and research and permanently deploy a crew to this facility. The ISS will vastly expand the human experience in living and working in space, encourage and enable commercial development of space, and provide a capability to perform unique, long duration, space-based research in cell and developmental biology, plant biology, human physiology, fluid physics, combustion science, materials science and fundamental physics. ISS will also provide a unique platform for making observations of the Earth’s surface and atmosphere, the sun, and other astronomical objects. The experience and dramatic results obtained from the use of the ISS will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The International Space Station is critical to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The International Space Station (ISS) is an international laboratory in low Earth orbit on which American, Russian, Canadian, European, and Japanese astronauts will conduct unique scientific and technological investigations in a microgravity environment. The goal of the Station is to support activities requiring the unique attributes of humans in space and establish a permanent human presence in Earth orbit. The proposed budget provides funding for the continued development of the vehicle and its research components and for current operations, assembly and utilization of the station. With several assembly missions successfully completed, the budget includes funding to keep subsequent assembly missions on schedule through U.S. Core Station Complete, currently planned for late 2003 – early 2004, and for early research commensurate with the buildup of on-orbit utilization capabilities and resources.

Extensive coordination with the user community is well underway, and payload facilities development and research and technology activities are coordinated with the Office of Biological and Physical Research (OBPR), the Office of Earth Science (OES) and the Office of Space Science (OSS). OBPR has administrative responsibility for the ISS Research program starting in FY 2000, responsibility for budget execution in FY 2002, and will gain budget formulation responsibility starting in FY 2003.

The ISS represents an unprecedented level of international cooperation. Space Station Partnership agencies include NASA, the Russian Aviation and Space Agency (Rosaviakosmos), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). International participation in the program has significantly enhanced the capabilities of the ISS.

Russian contributions to the ISS are significant, and include the Service Module, universal docking module, science power platform, docking compartment, life support module, and research modules. The Service Module provides early sleeping and living quarters for crew members. Russia is also providing logistics resupply and station reboosting capability with Progress vehicles, as well as crew transfers and emergency crew return using the Soyuz vehicle.

Canada's contribution to the ISS is the Mobile Servicing System (MSS) and its associated ground elements. The MSS will provide a second-generation robotic arm similar to the Canadian arm developed for the Shuttle. The MSS consists of the 58-foot long Space Station Remote Manipulator System (SSRMS) that can handle masses up to 220,000 pounds, a Base System, and a 12-foot robotic arm called the Special Purpose Dexterous Manipulator (SPDM) that attaches to the SSRMS. CSA has developed a Space Operations Support Centre, MSS Simulation Facility and Canadian MSS Training Facility.

The National Space Development Agency of Japan (NASDA) will provide the Japanese Experiment Module (JEM), which consists of a number of different components. Those components include the following elements: a Pressurized Module (PM), a pressurized laboratory that provides 77% of the utilization capability of the U.S. laboratory and can accommodate 10 racks; an Exposed Facility (EF) for up to 10 unpressurized experiments; a 32-foot robotic arm used for servicing system components on EF and changing out attached payloads; and an Experiment Logistic Module (ELM) for both pressurized and unpressurized logistics resupply, and the HII Transfer Vehicle (HTV) for ISS logistics resupply.

European Space Agency (ESA) contributions emphasize their role in early and continued utilization of the ISS and augmenting the ISS infrastructure. The ESA contributions include: the Columbus Orbital Facility (COF) with accommodations for 10 standard racks; the Automated Transfer Vehicle (ATV) for ISS logistics resupply, propellant resupply and reboost missions, to be launched by the Ariane 5 launch vehicle: and cooperation on the X-38. ESA has also made separate arrangement with the Russian Aviation and Space Agency for two contributions to the Russian elements: the European Robotic Arm (ERA) on the Russian Science and Power Platform and the Data Management System (DMSR) for the Service Module.

Additionally, there are several bilateral agreements between NASA and other nations such as Italy and Brazil, resulting in a total number of fifteen U.S. international partners. An agreement with ESA provides early research opportunities to them in exchange for provision of research equipment to the U.S. Another agreement with ESA provides the U.S. with Nodes 2 and 3 as an offset for the Shuttle launch for the Columbus Orbital Facility (COF). A similar Agreement in Principle with NASDA provides a Centrifuge, Centrifuge Accommodation Module (CAM), and Life Sciences Glovebox as an offset for the Shuttle launch of the Japanese Experiment Module (JEM). NASA and the Italian Space Agency have an agreement for Italy's provision of three Multi-Purpose Logistics Modules (MPLMs) in exchange for research opportunities. The Brazilian Space Agency (AEB) has become a participant in the U.S. ISS program by helping fulfill a portion of U.S. obligations to the ISS program in exchange for access to the U.S. share of ISS resources.

In FY 1999, successful launches of the first two components of the Station-the FGB control module and the first node were completed in November and December respectively, and the elements were assembled in orbit and activated. A third flight delivering supplies to support the first crews was successfully performed in May 1999. Between January 2000 and January 2001, the Russian Service Module, the Z1 and SO trusses, the control moment gyros, the first photovoltaic array and battery sets, initial thermal radiators, communication equipment, and the U.S. Laboratory were assembled on-orbit. A permanent human presence in space was achieved with the launch of Expedition 1. The first phases of multi-element integrated testing (MEIT) were completed. Crew training, payload processing, hardware element processing, and mission operations were supported. During the remainder of 2001, Expedition 2 will be deployed, and Phase 2 of the station assembly will be completed with the launch of the airlock. Preparations will continue for the start of Phase 3 and the first shuttle mission dedicated to research utilization is expected to be launched in mid-2002.

Russian Program Assurance (RPA) is contained within the Space Station budget and provides funding for contingency activities to address ISS program requirements resulting from delays or shortfalls on the part of Russia in meeting its commitments to the ISS program. Key elements of the RPA program have been the Interim Control Module (ICM), developed by the U.S. Naval Research Laboratory (NRL), and the U.S. Propulsion Module. With the successful launch of the Russian Service Module, and escalating costs for Space Station, including RPA components, NASA reassessed its Space Station priorities and the need for planned RPA hardware. In FY 2000, the ICM was placed in "call-up" mode and stored at NRL. Work on the original Propulsion Module design was terminated, and in FY 2001 funds for the Propulsion Module were redirected to cover cost increases in the baseline program. This left logistics contingency funding and funds for potential procurement of safety-related Russian goods and services in the RPA budget.

Based on recent operational experience, continuing flight software and hardware integration issues, obsolescence issues, and realization that earlier assembly phase cost estimates were low, NASA concluded that the program baseline could not be executed on schedule within approved funding levels. A reassessment of the ISS Program budget baseline was started in FY 2000 and continued into FY 2001. The initial results, based on conservative estimating assumptions, showed a budget shortfall of up to $4 billion over 5 fiscal years. To remain within the Agency's budget marks, NASA redirected funds from remaining high-risk, high-cost hardware development, including the Habitation Module and Crew Return Vehicle (CRV), as well as funds from the RPA budget mentioned above, to ensure that ISS would stay within budget, while assembly continues though U.S. Core Station Complete (deployment of Node 2 on flight 10A). This will allow for the integration of flight hardware being provided by the International Partners. In addition, the ISS Research Program is being realigned to match the on-orbit capability build-up as the program moves toward U.S. Core Complete. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Options for provision of a crew return capability and Habitat capability to support the desired increase in crew size from 3 to 6 will be discussed with the international partners. However, U.S. contributions to such capabilities will be dependent on the availability of funds within the President's five-year budget plan for Human Space Flight, technical risks, and the Administration's confidence in Agency cost estimates.

Over the next several years, the Agency will press ahead with ISS assembly and the integration of the partners' research modules. Research operations on board the ISS have been expanding since they began in FY 2000 and will greatly exceed any previous capabilities for research in space including Skylab, Shuttle, or Mir. During 2001, six pallets will be used in Space Shuttle missions. In FY 2001 and 2002, over 20 major and secondary payloads will be supported, including major hardware for ISS assembly.

NASA will also undertake reforms and develop a plan to ensure that future Space Station costs will remain within the President's FY 2002 Budget runout. Key elements of this plan will: 1) restore cost estimating credibility, including an external review to validate cost estimates and requirements and suggest additional options as needed; 2) transfer Space Station program management reporting from the Johnson Space Center in Texas to NASA Headquarters until a new program management plan is developed and approved; and 3) open future Station hardware and service procurements to innovation and cost saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION VEHICLE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Flight hardware	761,200	667,017	
Test, manufacturing and assembly	141,500	47,514	
Transportation support	47,400	2,395	
Total	950,100	716,926	

* FY 2002 funding is currently under review and allocations to Flight Hardware, Test, Manufacturing and Assembly Support, and Transportation will be determined as part of program assessments.

PROGRAM GOALS

Vehicle development of the International Space Station (ISS) provides an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, facility construction, Shuttle hardware and integration for assembly and operation of the station, mission planning, and integration of Space Station systems.

STRATEGY FOR ACHIEVING GOALS

Responsibility for providing Space Station elements is shared among the U.S. and our international partners from Russia, Europe, Japan, and Canada. The U.S. elements include nodes, a laboratory module, airlock, truss segments, photovoltaic arrays, three pressurized mating adapters, unpressurized logistics carriers, and a cupola. Various systems are also being developed by the U.S., including thermal control, life support, navigation, command and data handling, power systems, and internal audio/video. The U.S. funded elements also include the Zarya propulsion module provided by a Russian firm under the Boeing prime contract. Zarya was the first ISS element launched to orbit. Other U.S. elements being provided through bilateral agreements include the pressurized logistics modules provided by the Italian Space Agency, Nodes 2 and 3 provided by ESA, and the centrifuge accommodation module (CAM) and centrifuge provided by the Japanese.

Canada, member states of the European Space Agency (ESA), Japan, and Russia are also responsible for providing a number of ISS elements. The Japanese, ESA, and Russia will provide laboratory modules. Canada will provide a remote manipulator system, vital for assembly and maintenance of the station. The Russian Aviation and Space Agency (Rosaviakosmos) is also providing significant ISS infrastructure elements including the Service Module (SM), science power platform, Soyuz crew transfer and emergency crew return vehicle, Progress resupply vehicles, and universal docking modules.

The Boeing Company is the prime contractor for the design and development of U.S. elements of the International Space Station. It also has prime responsibility for integration of all U.S. and International Partner contributions and for assembly of the ISS. At their Huntington Beach site location (formerly McDonnell Douglas), Boeing is developing and building the integrated truss segments that support station elements and house essential systems, including central power distribution, thermal distribution, and attitude control equipment. Other Boeing locations are also supporting the flight hardware build to mitigate capability shortfalls at Huntington Beach. Additionally, major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems are being developed at Huntington Beach.

U.S. pressurized modules are being developed by Boeing at their Huntsville site location, and by ESA and Japan. The second flight to ISS, successfully conducted in December 1998, deployed Unity, a pressurized node which contains four radial and two axial berthing ports. Attached to the Node were two pressurized mating adapters (PMAs), which serve as docking locations for the delivery of the U.S. Laboratory Module and the Multi-Purpose Pressurized Logistics Module. Under a bilateral agreement, ESA is providing Nodes 2 and 3 and a cupola to the U.S. Node 2 is currently manifested for flight during the first quarter of FY 2004. The Cupola and Node 3 are nominally scheduled after the U.S. Core Complete, and their status is being evaluated as part of the ongoing reassessment activities.

The power truss segments and power system, essential to the Station's housekeeping operations and scientific payloads, are being built by Boeing at their Canoga Park location (formerly Rocketdyne Division, Rockwell International). Four photovoltaic elements, each containing a mast, rotary joint, radiator, arrays, and associated power storage and conditioning elements, comprise the power system. The fourth power array is nominally scheduled after the U.S. Core Complete, and its status is being evaluated as part of the ongoing reassessment activities.

The vehicle program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. These “in-line” products and services include: test capabilities; the provision of government-furnished equipment (GFE) (including flight crew systems, environment control and life support systems, communications and tracking, and extravehicular activity (EVA) equipment); and engineering analyses. As such, they support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Transportation support provides those activities that allow the Space Shuttle to dock with the Space Station. This budget funded the development and procurement of two external Shuttle airlocks, and upgrade of a third airlock to full system capability, which were required for docking the Space Shuttle with the Russian Mir as well as for use with the Space Station. Other items in this budget include: the Shuttle Remote Manipulator System (RMS) and Space Shuttle mission training facility upgrades; development of a UHF communications system and a laser sensor; procurement of an operational space vision system; procurement of three docking mechanisms and Space Station docking rings; EVA/Extravehicular Mobility Units (EMU) services and hardware; and integration costs to provide analyses and model development.

In order to ensure that the Space Station budget remains within the President’s five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

Schedules and outputs are under review, and will be adjusted as part of the ongoing program reassessment.

SCHEDULE & OUTPUTS

Completed Incremental Design Review (IDR) Performed Stage Integration Reviews (SIR)	A series of incremental, cumulative reviews throughout the design phase to assure that system level requirements are properly implemented in the design, have traceability, and that hardware and software can be integrated to support staged assembly and operation. IDR #1 performed these functions for flights 1A/R through 6A. Subsequently, IDR #2 assessed design progress for flights 1A/R through 7A. IDR#2B assessed the entire Space Station assembly sequence. IDRs have been replaced by Stage Integration Reviews (SIR), a more classical critical design review approach on a stage-by-stage basis which review groupings of flights with assembly hardware and functionality/performance linkages across the stage. • *Performed SIR 1 for flights through 2A (4th Qtr FY 1997)* • *Performed SIR 2 for flights through 4A (1st Qtr FY 1998)* • *Performed SIR 3 for flights through 6A (2nd Qtr FY 1998)* • *Performed SIR 4 for flights through 4R (1st Qtr FY 1999)* • *Performed SIR 5 for flights through UF-2 (4th Qtr. FY 1999)* • *Performed SIR 6 for flights through 11A (2nd Qtr FY 2000)* • Perform SIR 7 for flights through 12A.1 (3rd Qtr FY 2001) • Perform SIR 8 for flights through UF-4 (1st Qtr. FY 2002) • Perform SIR 9 for flights through 10A.1 (2nd Qtr FY 2002)

Prime Development Activity

NOTE: All activities listed are planning milestones, and are not contractual. Flights subject to change during reassessment.

Flight 1A/R: Zarya (FGB Energy Block) (First Element Launch) (Proton Launch Vehicle) Planned (Rev B): November 1997 Revised (Rev D Mod): November 1998 Completed November 1998	Self-powered, active vehicle; provides attitude control through early assembly stages; provides fuel storage capability after the service module is attached; provides rendezvous and docking capability. • Completed factory ground testing of first flight unit (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998) • Completed flight software (slip from 3rd Qtr FY 1997 to 1st Qtr FY1998) • Delivered FGB flight article to Baikanour (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998) • Installed solar arrays in FGB flight article (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998)

- Removed Zarya from storage and complete deconservation (1st Qtr FY 1999)
- Mated FGB to Launch Vehicle (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999)
- On-Orbit checkout, Service Module docking, fuel transfer (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999)
- Launch of the Zarya (1st Qtr FY 1999)

Flight 2A: Unity (Node 1), Pressurized Mating Adapters (PMA-1, PMA-2) Planned (Rev B): December 1997 Revised (Rev D Mod): December 1998 Completed December 1998	Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1stowage rack; PMA-1 provides the interfaces between U.S. and Russian elements; PMA-2 provides a Space Shuttle docking location. • Completed Node STA static flight loads testing (slip from 4th Qtr FY 1997 to 1st Qtr FY 1998) • Completed mating of PMA-1 to Node (1st Qtr FY 1998) • Completed flight 2A Cargo Element Integration and Test (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Completed mating of PMA-2 to Node (3rd Qtr FY 1998) • Space Shuttle Payload Integration and Test (slip from 1st Qtr FY 1998 to1st Qtr FY 1999) • Launch of Unity (flight 2A) (1st Qtr FY 1999)
Flight 2A.1 Logistics Planned (Rev C): December 1998 Revised (Rev D Mod): 3rd Qtr FY 1999 Completed June 1999	Double Spacehab flight for logistics/resupply during early assembly. • Station Cargo Integration Review (SCIR) (2nd Qtr FY 1998) • Flight Operations Review (FOR) (2nd Qtr FY 1999) • Hardware on dock at KSC (2nd Qtr FY 1999) • Begin integration of critical spares into Spacehab Module (2nd Qtr FY1999) • Delivery of Strela Cargo Crane to Integrated Cargo Carrier integration (2nd Qtr FY 1999) • Launch of flight 2A.1 (3rd Qtr FY 1999)

Flight 3A: Z1 Truss Segment, Control Moment Gyros (CMGs), PMA-3, KU-Band Planned (Rev B): July 1998 Revised (Rev D Mod): 1st Qtr FY 2000 Revised (Rev E): 2nd Qtr FY 2000 Revised Target: 3rd Qtr FY 2000 Revised (Rev F): 1st Qtr FY 2001 Completed: October 2000	Z1 Truss allows temporary installation of the P6 photovoltaic module to Node 1 for early U.S. based power; KU-band and CMGs support early science capability; PMA-3 provides a Space Shuttle docking location for the lab installation on flight 5A. • Completed CMG qualification and flight testing (2nd Qtr FY 1998) • Z1 modal and static qualification tests complete (slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • PMA-3 on-dock at KSC (Slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • KU-Band antenna on dock at KSC (3rd Qtr FY 1998) • S-Band antenna on dock at KSC (3rd Qtr FY 1998) • Z1 flight unit completed and shipped to KSC (3rd Qtr FY 1998) • Plasma Contactor and DDCU-HP Qualification Testing complete (4th Qtr FY1999) • 3A MEIT complete (2nd Qtr FY 2000) • Complete Z1 final outfitting (3rd Qtr FY 2000) • Launch Flight 3A (1st Qtr FY 2001)
Flight 4A: P6 Truss segment, Photovoltaic Array, Thermal Control System (TCS) Radiators, S-Band Equipment Planned (Rev B): November 1998 Revised (Rev D Mod): 1st Qtr FY 2000 Revised (Rev E): 2nd Qtr FY 2000 Revised Target: 4th Qtr FY 2000 Revised (Rev F): 1st Qtr FY 2001 Completed: November 2000	This flight provides the first U.S. solar power via solar arrays and batteries, cooling capability and S-Band system activation. • Beta Gimbal Assembly to P6 Integration (3rd Qtr FY 1998) • IEA/Long Spacer ready for integration and test (4th Qtr FY 1998) • Z1/P6 on dock KSC for MEIT (4th Qtr FY 1998) • Radiator Qualification Testing complete (2nd Qtr FY 1999) • Solar Arrays on-dock KSC (2nd Qtr FY 1999) • Flight Radiators delivered to P6 Outfitting (1st Qtr FY 2000) • 4A MEIT complete (2nd Qtr FY 2000) • Launch flight 4A (1st Qtr FY 2001)

Flight 5A: U.S. Laboratory, 5 Lab System Racks Planned (Rev B): December 1998 Revised (Rev D Mod): 2nd Qtr FY 2000 Revised (Rev E): 3rd Qtr FY 2000 Revised Target: 4th Qtr FY 2000 Revised (Rev F): 2nd Qtr FY 2001 Completed: February 2001	Launch of the U.S. Laboratory Module establishes initial U.S. user capability; launches with 5 system racks pre-integrated; KU-band and CMGs are activated. • Complete installation of 5A/6A Racks in Lab for testing (3rd Qtr FY 1998) • Lab on dock at KSC (1st Qtr FY 1999) • Lab Acceptance Testing Complete (4th Qtr FY 2000) • Deliver Command and Control and Guidance Navigation and Control Software to Lab (4th Qtr FY 2000) • Complete 5A MEIT (2nd Qtr FY 2000) • Launch of flight 5A (2nd Qtr FY 2001)
Flight 5A.1: MPLM flight module-1, 6 Lab System Racks, 1 Payload Rack Planned: 2nd Qtr FY 2000 Revised (Rev E): 3rd Qtr FY 2000 Revised Target: 1st Qtr FY 2001 Revised (Rev F): 2nd Quarter FY 2001 Completed: March 2001	Continues the outfitting of the U.S. Lab, with the launch of 6 system racks. This flight also represents the first use of science with the launch of the Human Research Facility (HRF) rack. It is also the first use of the Multi-Purpose Logistics Module (MPLM). • Complete MPLM Integration and Test (4th Qtr FY 1998) • MPLM on-dock at KSC (4th Qtr FY 1998) • Integration of HRF Sub-racks into the HRF rack (4th Qtr FY 1999) • HRF rack on-dock at KSC (4th Qtr FY 2000) • Early Ammonia Servicer On-Dock KSC (1st Qtr FY 2001)) • MPLM Rack Installation/Closeout (1st Qtr FY 2001) • Launch of 5A.1 (2nd Qtr FY 2001)
Flight 6A: MPLM flight module-2, Canadian Remote Manipulator System, UHF Planned (Rev B): January 1999 Revised (Rev D Mod): 3rd Qtr FY 2000 Revised (Rev E): 4th Qtr FY 2000 Revised Target: 1st Qtr FY 2001 Revised (Rev F): 3rd Qtr FY 2001	Continues U.S. lab outfitting with delivery of 2 stowage and 2 EXPRESS payload racks; UHF antenna provides space-to-space communication capability for U.S. based EVA; delivers Canadian SSRMS needed to perform assembly operations of later flights. • SSRMS On-dock KSC (3rd Qtr FY 1999) • Complete Integration and Test of MPLM FM2 (4th Qtr FY 1999) • MPLM FM2 On-dock KSC (4th Qtr 1999) • SSRMS and RWS Software complete (2nd Qtr FY 2000) • 6A MEIT Complete (2nd Qtr FY 2000) • MPLM Rack Integration / Closeout (2nd Qtr FY 2001) • Launch of flight 6A (3rd Qtr FY 2001)

Flight 7A:
Airlock, High Pressure Gas Tanks (HPGT)
Plan (Rev B): April 1999
Revised (Rev D Mod): 4^{th} Qtr FY 2000
Revised (Rev E): 4^{th} Qtr FY 2000
Revised Target: 2^{nd} Qtr FY 2001
Revised (Rev F): 3^{rd} Qtr FY 2001

Launches the airlock and installs it on orbit. The addition of the airlock permits ISS-based EVA to be performed without loss of environmental consumables such as air.

- Completed Airlock Integration/A&CO (2nd Qtr FY 1999)
- Airlock System Software Complete (2nd Qtr FY1999)
- Element level testing complete (2nd Qtr FY 2001)
- Airlock on dock at KSC (4th Qtr FY 2000)
- Complete SLP integration (2nd Qtr FY 2001)
- Launch flight 7A (3rd Qtr FY 2001)

Flight 7A.1
MPLM, SLP pallet
Planned (Rev B): November 1999
Revised (Rev D Mod): 4^{th} Qtr FY 2000
Revised (Rev E): 1^{st} Qtr FY 2001
Revised Target: 2^{nd} Qtr FY 2001
Revised (Rev F): 3^{rd} Qtr FY2001

Logistics and utilization mission delivering resupply/return stowage racks resupply stowage platforms, and two EXPRESS payload racks. This flight will carry critical spares as well as various resupply items. First re-use of MPLM FM-1

- MPLM available from 5A.1 (2^{nd} Qtr FY 2001)
- MPLM on-dock at KSC (4th Qtr FY 1998)
- MPLM Rack Installation/Closeout (3rd Qtr FY 2000)
- Launch of 7A.1 (3rd Qtr FY 2001)

Flight 8A:
S0 Truss, Mobile Transporter
Plan (Rev B): June 1999
Revised (Rev D Mod): 2^{nd} Qtr FY 2001
Revised (Rev E): 2^{nd} Qtr FY 2001
Revised Target: 3^{rd} Qtr FY 2001
Revised (Rev F): 2^{nd} Qtr FY 2002

S0 is the truss segment that provides attachment and umbilicals between pressurized elements and truss mounted distributed systems/utilities. Mobile Transporter provides SSRMS translation capability along the truss.

- Complete S0 flight fabrication, assembly, and outfitting (3rd Qtr FY 1999)
- S0 on dock at KSC (3rd Qtr FY 1999)
- Complete S0 STA Testing (4th Qtr FY 1999)
- Complete Mobile Transporter flight article (4th Qtr FY 1999)
- Command and Control Software Complete (3rd Qtr FY 2001)
- 8A MEIT Complete (4th Qtr FY 2001)
- Launch flight 8A (2nd Qtr FY 2002)

Flight 9A:
S1 Truss, CETA Cart
Plan (Rev B): September 1999
Revised (Rev D Mod): 3rd Qtr 2001
Revised (Rev E): 4th Qtr FY 2001
Revised Target: 1st Qtr FY 2002
Revised (Rev F): 3rd Qtr FY 2002

S1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss.

- Complete second S-band string (4th Qtr FY 1998)
- Radiators complete for S1 Integration (2nd Qtr FY 2000)
- Complete S1 STA testing (2nd Qtr FY 2000)
- Complete S1 flight Outfitting and Acceptance Testing (2nd Qtr FY 2000)
- S1 on dock at KSC (1st Qtr FY 2001)
- 9A MEIT Complete (4th Qtr FY 2001)
- Launch flight 9A (3rd Qtr FY 2002)

Flight 11A:
P1 Truss (3 Radiators), TCS, CETA, and UHF Band Communications
Plan (Rev B): January 2000
Revised (Rev C): 1st Qtr FY 2001
Revised (Rev E): 4th Qtr FY 2001
Revised Target: 2nd Qtr FY 2002
Revised (Rev F): 1st Qtr FY 2003

P1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss.

- Radiators complete for P1 Integration (2nd Qtr FY 2000)
- P1 on dock at KSC (4th Qtr FY 2000)
- Complete P1 flight Acceptance Testing (2nd Qtr FY 2001)
- CETA Cart Ready for P1 Integration (2nd Qtr FY 2001)
- Pump Module ready for P1 Integration (2nd Qtr FY 2001)
- 11A MEIT Complete (4th Qtr FY 2001)
- Launch flight 11A (1st Qtr FY 2003)

Non-Prime Development Activity

Non-prime development activities continue in FY 2001 and FY 2002. Schedules and outputs are under review, and will be adjusted as part of the ongoing program reassessment.

Global Positioning System (GPS)

Provides autonomous, real-time determination of Space Station's position, velocity, and attitude.

- Delivered GPS Antenna Assembly (4th Qtr FY 1997)
- Delivered GPS Receiver/Processor (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1999)

Extra-Vehicular Activity System	Provides Government Furnished Equipment (GFE), EVA unique tools, and EVA support equipment for the Space Station. Provides EVA development and verification testing. Provides for operation of the WETF/NBL and the maintenance of neutral buoyancy mockups to support Station EVA development activities. • Delivered Crew Equipment Transfer Aid (CETA) Cart proto-flight unit (slip from 1st Qtr FY 1997 to 1st Qtr FY2000) • Delivered EVA Tool Storage Device (ETSD) for CETA Cart (1st Qtr FY 1998) • Delivered ETSD for airlock (1st Qtr FY 1998) • Delivered canisters for the Regenerable CO2 System (3rd Qtr FY 1998) • Delivered 1st Flight Regenerator for the Regenerable CO2 System (3rd Qtr FY 1998) • ORU Transfer Device (OTD) flight unit delivered (1st Qtr FY 1999)
Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development; housekeeping management; portable breathing apparatus; restraints and mobility aids; tools, diagnostic equipment and portable illumination kit. • Completed 6A Operations and Personal Equipment CDR (1st Qtr FY 1997) • Delivered Restraints and Mobility Aids (1st Qtr FY 1997) • Completed CDR for portable illumination (2nd Qtr FY 1997) • Completed production of tools and diagnostic flight hardware kit (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Completed Personal Hygiene Kit PRR Preliminary/Program Requirements Review (2nd Qtr FY 1998) • Delivered Maintenance Workstation Kit, Portable Illumination, and Housekeeping Kit (4th Qtr FY 1998)
Airlock Service And Performance Checkout Unit	Provides flight servicing, performance unit, and certification unit, Russian space suit support hardware interface definition and documentation, test plans and reports, mockups, and thermal analysis. • Delivered Qual hardware to airlock test article (Slip from 2nd Qtr FY 1997 to 2nd Qtr FY 1999) • Final Flight Unit Deliveries (2nd Qtr FY 2000)

ACCOMPLISHMENTS AND PLANS

FY 2000 activities focused on the preparations and launches required for Phase 2/3 assembly of the International Space Station. These activities included:

· Flight 2A.2, which was added to the assembly sequence in early FY 1999, and was then divided into two separate flights (2A.2a and 2A.2b) in order to accomplish the FGB life extension after the Service Module launch was postponed to July 2000. Flight 2A.2 was to include internal and external spares and supplies, as well as station outfitting equipment. The first of the two flights (2A.2a), was remanifested to perform FGB lifetime and maintenance tasks before SM arrival. The second, 2A.2b, was flown after delivery of the SM to perform SM outfitting for the Expedition One crew arrival.

· Flight 2A.2a, STS-101, was launched on May 19, 2000 to ferry supplies required by the Expedition One crew, as well as to replace electronics in the Russian built Zarya module. This flight extended *Zarya's* service life through December 2000.

· Flight 1R (SM): The failure of two successive Proton launches in 1999 (July and October) caused a delay in the Service Module launch date since the SM was to be launched on a Russian Proton rocket. This slipped the launch into Summer 2000, causing NASA to take measures to prolong the life of the orbiting FGB module beyond its original service certification. The SM was launched successfully on July 12, 2000 from Baikonur. The SM provides propulsion capability, living quarters and life support for the early ISS crews. The SM docked with the orbiting ISS on schedule two weeks later (July 25),

· Flight 1P: SM docking was quickly followed by the first Russian progress resupply mission on August 6, 2000.

· Flight 2A.2b (STS-106) launched on September 8, 2000 and delivered supplies and outfitted the SM in preparation for the following assembly mission STS-92 (flight 3A), with the Z1 Truss and PMA-3.

FY 2001 activities to date have established a permanent crew on the ISS, deployed the first U.S. solar array to provide power, and launched and activated the U.S. Lab, including the capability for control and communication.

· Flight 3A: The Z1 truss and PMA-3 were launched on October 11, 2000. The Z1 Truss was attached to the Node 1 zenith location, and the PMA-3 attached to Node 1 nadir.

· The Expedition 1 Crew (Flight 2R) launched on October 31, 2000 from Baikonur with three astronauts (Commander Bill Shepherd, Pilot Yuri Gidzenko and Flight Engineer Sergei Krikalev) aboard a Soyuz module which also serves as the crew return capability for the ISS.

· Flight 2P: The launch of Russian Progress flight 2P on November 16, 2000.

· Flight 4A launched the Integrated Equipment Assembly (IEA), Photovoltaic (PV) Array, Early External Active Thermal Control System (EEATCS), and the P6 truss segment on November 30, 2000. This cargo element completed Integrated Electronic Assembly (IEA) integration in September in preparation for being turned over to the space shuttle integration team in FY 2001.

· Flight 5A, U.S. Lab MEIT was completed in the second quarter of FY 2000. Flight 5A/5A.1 racks have been installed, and remaining Lab testing at KSC was completed in the first quarter of FY 2001. The Lab was successfully launched in February 2001.

· Flight 5A.1, added to the assembly sequence in early FY 1999, is the first use of the Multi-Purpose Logistics Module (MPLM). The MPLM for flight 5A.1 completed its integration and testing and was delivered to KSC. The Human Research Facility (HRF) Rack, which represents the first utilization of the ISS for science/experiments, completed the integration of its Sub-racks and was delivered to KSC in the fourth quarter of FY 2000. The MPLM with the HRF was successfully launched in March 2001.

FY 2001 will see the finish of Phase 2 of the ISS Program. FY 2002 will see the beginning of Phase 3 of the ISS assembly sequence, and the beginning construction of the middle truss on the station's backbone (Z1 Truss) launched the previous year. Two Utilization Flights and one outfitting/logistics flight will enable a broader range of research to be conducted as ISS assembly continues. Activities in preparation for these flights include:

· Flight 6A will complete U.S. Lab outfitting with the first launch of the MPLM "Rafaello". Flight 6A also delivers the robotic arm, which is essential to continued assembly of the ISS. The SSRMS completed MEIT activities in the 2nd Qtr of FY 2000 and has been integrated onto the SLP for launch in the 3rd Quarter FY 2001. . There are two EXPRESS payload racks scheduled to be launched on flight 6A. One of these racks is the first use of an Active Rack Isolation System (ARIS) EXPRESS rack. Both of the EXPRESS racks completed their MEIT activities and were integrated into the MPLM in the 2nd Qtr of FY 2001.

· The sixth U.S. mission planned for FY 2001, Flight 7A, will carry the airlock. Once installed, the airlock will provide the station an independent EVA capability, and will bring to a close Phase 2 of ISS assembly. The airlock was delivered to KSC 4th quarter FY 2000, with a post delivery checkout scheduled in early FY 2001. The airlock is on schedule for flight in 3rd Quarter FY 2001.

Activities in FY 2002 include:

· Major flight hardware launches scheduled for FY 2002 include the truss segments for flights 8A (S0) and 9A (S1).

· Completion of 3 of the 4 Multi-Element Integrated Test (MEIT) conditions for flight elements required for assembly flights 8A through 12A.

· Complete final integration and testing of truss segments P3/P4 and S3/S4 with their solar arrays for construction of the middle truss in FY 2003.

· Demonstration of station-based EVA to support up to 30 EVA's from the U.S. Airlock each year.

· Conduct permanent on-orbit operations, providing an estimated 8,000 hours of ISS crew support to station assembly, operations, and research.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION OPERATIONS CAPABILITY

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Operations capability & construction...	53,700	40,000	
Vehicle operations..	390,500	357,500	
Ground operations..	259,400	427,182	
[Construction of Facilities included]	[56]	[--]	
Total...	703,600	824,682	

* FY 2002 funding is currently under review and allocations to Ops Capability & Construction, Vehicle Ops, and Ground Ops will be determined as part of program assessments.

PROGRAM GOALS

The primary objective of the operations program is to safely and reliably assemble, activate, integrate, and operate the ISS. This requires a significant level of ground support including tactical planning, resource allocations, off-nominal situations planning, detailed manifests, stowage planning, imagery planning, crew and ground controller training, flight procedures and crew activity plan development, visiting vehicle operations plans, ISS logistics and maintenance, flight rules and ground procedure development, and real-time operations support. The years of hardware engineering, manufacturing, and testing leading to the final acceptance and launch of various ISS elements is now in the final stages as transition of the International Space Station (ISS) vehicle program to the operations program is taking place. Planning and procurements, element specific operations and anomaly preparation, and detailed integration of all capabilities and constraints of elements and ground systems are occurring across the partnership to ensure the pieces and people operate as one system. The second major goal is to perform operations in a simplified and affordable manner. This includes NASA's overall integration of distributed operations and integration functions to be performed by each of the international partners in support of their elements.

The first crew was launched to ISS in October 2000, setting in motion a progression of international crews who will permanently inhabit the ISS, beyond the confines of Earth. The logistics of providing the crew with what is needed for them to live and productively work in the isolated and harsh environment of space for 24 hour a day, 365 days per year is now a nominal part of ISS activities. This is the first time since the Skylab era in the 1970's, and the Shuttle-Mir program, that the U.S. will have an extended human presence in space. Because of its massive size and level of international participation, the ISS assembly period will span half a decade, with ISS infrastructure and logistics deployed over multiple flights from launch vehicles across the globe. Because of the program's complexity, the Space Station team has done extensive planning for operations of several different ISS vehicle configurations on orbit. Each time an element is added to the current station, the flight characteristics and internal systems change, and the ISS stack on-orbit becomes essentially a different vehicle with different thermal constraints, drag coefficients, and other characteristics. The Space Station Program will draw on the experience derived from Skylab, the Shuttle-Mir program, and that gained from operating the Space Shuttle for nearly two decades to address the unique circumstances of building and operating an ever changing ISS vehicle. With each successive docking of an ascent vehicle to the ISS and the transfer of its contents to the ISS, and with each increment of operations, the Program will evaluate its methods and lessons learned to develop even more efficient and effective operations.

STRATEGY FOR ACHIEVING GOALS

The Space Station operations concept emphasizes multi-center and multi-program cooperation and coordination. Operations capability development and construction provides a set of facilities, systems, and capabilities to conduct the operations of the Space Station. For the U.S. segment, the work will primarily be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). KSC has developed launch site operations capabilities for conducting pre-launch and post-landing ground operations. JSC has developed space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. As ISS partners become operational, their respective ground operations functions are integrated by NASA into the unified command and control architecture, similar to that already in operation for Mission Control Center-Moscow (MCC-M) located in Korolev. The Mission Control Center-Houston (MCC-H) will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite system (TDRSS) system and Russian communication assets.

Beyond ISS specific operations, a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command and control, as well as training at JSC. The initial Space Station Training Facility capability is now operational and ISS crews are currently in training. Utilizing lessons learned from Shuttle-Mir, ISS crew training is knowledge and proficiency-based rather than timeline and detailed procedures based, as has been the case for the Shuttle crews.

Space Station vehicle operations provide systems engineering expertise and analysis to sustain the performance and reliability of Space Station hardware and software systems. Sustaining engineering will continue to be consolidated and performed at the Johnson Space Center (JSC). Maintenance and repair costs continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware spares and repair costs will continue to be controlled by establishing a maintenance and repair capability including hardware depots that effectively utilize Kennedy Space Center (KSC) and original equipment manufacturers or other certified industry repair resources.

Flight controllers are being trained to operate the Space Station as a single integrated vehicle, with full systems capability in the training environment. Crewmembers are being trained in the Neutral Buoyancy Lab (NBL) and Space Station Training Facility (SSTF) on systems, operations, and other activities expected during a mission. Part-task and full hardware mockups and simulators are also being used to provide adequate training for the crew prior to flight. Integrated training, consolidation of payload and systems training facilities, and the concept of proficiency-based learning and onboard training will increase the efficiency of the overall training effort.

Engineering operations support provides analysis, systems definition, development, and implementation to ensure that a safe and operationally viable vehicle is delivered and can be maintained. Functions include the following: vehicle design participation and assessment, operations product development, ground facility requirements and test support, ground display and limited applications development, resource planning, crew systems and maintenance, extravehicular activity (EVA), photo/TV training, operations safety assessments, medical operations tasks, mission execution and systems performance assessment, and sustaining engineering.

Cargo integration support provides accurate, timely, and cost effective planning and layout of cargo stowage items, analytical analysis of cargo/transport systems compatibility, and physical integration of cargo items into the transport carriers and on-orbit ISS stowage systems. Launch site processing begins prior to the arrival of the flight hardware at KSC with requirement definition and processing planning. Upon arrival at KSC, the flight hardware will undergo various processes, dependent upon the particular requirements for that processing flow. These processes may include: post delivery inspection/verification, servicing, interface testing, integrated testing, close-outs, weight and center of gravity measurement, and rack/component to carrier installation.

In order to ensure that the Space Station budget remains within the President's five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Operations is a critical area of this program reassessment. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

SCHEDULE & OUTPUTS

Schedule and outputs are under review as part of the program reassessment, and the preliminary information provided below is subject to change.

Space Station Training Facility (SSTF)

The SSTF is the primary facility for integrated space systems operations training and procedures verification. A flight simulation software load is built for every configuration of the ISS. These loads are delivered according to established templates defined by requirements that ensure adequate time to complete crew and flight controller training before the beginning of a mission. These deliveries have supported training for several ISS crew and ground control teams.

Completed:

- SSTF Initial Ready for Training (RFT) for flight 5A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 5A (4th Qtr FY 2000)
- SSTF Initial RFT for Flight 5A.1 (4th Qtr FY 2000)
- SSTF Final RFT for Flight 5A.1 (1st Qtr FY 2000)

- SSTF Initial RFT for flight 6A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 6A (2nd Qtr FY 2000)
- SSTF Initial RFT for flight 7A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 7A (2nd Qtr FY 2001)
- SSTF Initial RFT for flight 7A.1 (2nd Qtr FY 2000)

Planned:

- SSTF Final RFT for flight 7A.1 (3rd Qtr FY 2001)
- SSTF Initial RFT for flight 8A (4th Qtr FY 2001)
- SSTF Final RFT for flight 8A (1st Qtr FY 2002)
- All RFT dates for flights beyond 8A are template dates

<u>Mission Control Center (MCC)</u>

This facility provides integrated command and control capabilities and support to real-time increment operations. This facility consists of a Space Shuttle flight control room, an ISS flight control room, a training flight control room, many backroom support rooms and equipment to support all of these activities. Software loads are built to support flights and simulations as required by training and flight support templates. End-to-end testing between MCC-H and MCC-M has been completed and flight support is ongoing with these two centers. Houston (MCC-H) was in a flight-following mode of operations until flight 5A, when MCC-H became the lead center for real-time command and control of the ISS.

- Mission Control Center ready to support use of ICM (Note: requirement deleted upon successful launch of Russian Service Module)
- MCC Post Mariner Delivery (2nd Qtr FY 2000)
- Delivery to support flight 5A ISS Command and Control Capability (1st Qtr FY 2001)
- Complete backup control center (control center development complete) (3rd Qtr FY 2001) MCC Io Delivery in support of 5A (1st Qtr FY 2001)

<u>Baseline Increment Definition And Requirements Document (IDRD)</u>

The IDRD is the ISS Program requirements document that defines all Program requirements for each ISS increment. Release of this document officially initiates increment specific Product and training Development. This typically occurs at 12 months in advance of the increment.

For Planning Period 3	For Planning Period 4	For Planning Period 5	For Planning Period 6
Plan: May 1999	Plan: May 1999	Plan: June 2002	Plan: October 2002
Revised: February 2000	Revised: July 2001		
Actual: August 2000			

Increment Operations Reviews (IOR)

Prior to each mission or the start of an increment a series of reviews are conducted to ensure complete readiness for a flight or increment in all areas. These reviews are held according to a “launch minus” template with the dates driven by major milestones such as final installation of cargo into the Shuttle. These reviews are chaired by Program management.

IOR for Increment 1
Plan: Sept 1999
Revised: February 2000
Actual: February 2000

IOR for Increment 2
Plan: Dec 1999
Revised: March 2000
Actual: August 2000

IOR for Increment 3
Plan: March 2000
Revised: February 2001

IOR for Increment 4
Plan: November 2000
Revised: June 2001

IOR for Increment 5
Plan: November 2001

IOR for Increment 6
Plan: February 2002

IOR for Increment 7
Plan: June 2002

IOR for Increment 8
Plan: October 2002

Certificate of Flight Readiness (CoFR) Reviews

The CoFR process enables assessment and certification of the successful completion of program activities that are required to ensure mission success. This objective is accomplished by ensuring the certification of the safety and operational readiness of the ISS Program hardware/software, facilities, and personnel that support pre-launch activity, launch/return, on-orbit assembly, operations, and utilization.

Flight 2A.2a Reviews
LPRR: March 2000
PRR: March 2000
SORR: March 2000
FRR: April 2000
PFR: June 2000

Flight 2A.2b Reviews
LPRR: July 2000
PRR: August 2000
SORR: August 2000
FRR: August 2000
PFR: December 2000

Flight 4A Reviews
LPRR: October 2000
PRR: November 2000
SORR: November 2000
FRR: November 2000
PFR: December 2000

Flight 5A Reviews
LPRR: November 2000
PRR: December 2000
SORR: January 2000
FRR: February 2000
PFR: February 2000

Flight 6A Reviews
MRR: October 2000
LPRR: March 2001
PRR: March 2001
SORR: March 2001
FRR: April 2001
PFR: May 2001

Flight 7A Reviews
LPRR: April 2001
PRR: April 2001
SORR: April 2001
FRR: May 2001
PFR: May 2001

Flight UF1 Reviews
LPRR: August 2001
PRR: TBD
SORR: September 2001
FRR: September 2001
PFR: October 2001

Flight 8A Reviews
LPRR: November 2001
PRR: TBD
SORR: December 2001
FRR: January 2002
PFR: January 2002

Flight 3A Reviews	Flight 5A.1 Reviews	Flight 7A.1 Reviews	Flight UF2 Reviews
MRR: June 2000	MRR: September 2000	LPRR: May 2001	LPRR: January 2002
LPRR: August 2000	LPRR: January 2001	PRR: TBD	PRR: TBD
PRR: September 2000	PRR: February 2001	SORR: May 2001	SORR: January 2002
SORR: September 2000	SORR: February 2001	FRR: June 2001	FRR: February 2002
FRR: September 2000	FRR: February 2001	PFR: July 2001	PFR: March 2002
PFR: December 2000	PFR: March 2001		

ACCOMPLISHMENTS AND PLANS

FY 2000

During FY 2000, preparation for the initial operation of ISS with the three-person permanent crew was successfully performed. Space Station Operations supported U.S. missions 2A.2a, 2A.2b, and readiness for 3A, and 4A. It supported Russian missions delivering the Service Module and a Progress logistics resupply to ISS. The Service Module (SM) was a major milestone for the ISS in that it contained the life support and crew stations for three crewmembers.

The Zvezda Service Module was launched without a crew aboard and docked with the orbiting ISS by remote control. In addition to early station living quarters, the SM also provides life support, navigation, communications, guidance and propulsion to the new station. Flights 2A.2a and 2A.2b, both logistics flights, were primarily conducting transfers of logistics and supplies to the new space station. The 2A.2a and 2A.2b crews also began orbital checkout and setup of the new living quarters. In addition, a spacewalk was performed to install the Russian Strela crane's telescoping boom.
Expedition 1 crew trained in Russia for 14 additional weeks before launching on a Soyuz. While the Expedition 1 crew was in Russia they participated in three remote training sessions in which they were able to connect back to the Space Station Training Facility (SSTF) located in Houston. This was a first for the Expedition crew to participate in a US training session remotely from Russia. Plans are to continue to use this capability for training future Expedition crews.

Since Shuttle flights average 10 days, the Shuttle crew typically trains up to the launch of the mission. However with ISS missions lasting 3 to 4 months, the Expedition crews continue to train for some objectives in flight. The use of on-board training to stay proficient with critical tasks that they might have to perform during the mission was initiated for the Expedition 1 crew. This training ranges from emergency drills to procedure reviews to computer based training (CBT).

Some Soyuz introduction training for all of the ISS astronauts is conducted at JSC. The Russian Orlan EVA spacesuit has been integrated into the Neutral Buoyancy Lab (NBL) and the US EVA spacesuit has been integrated into the Russian Hydrolab. This gives NASA the capability to train on either spacesuit in the US or Russia.

FY 2001

In FY 2001 the ISS program is conducting the first year of permanently crewed on-orbit operations. It will also be the first year of U.S. leadership of the primary real time ISS vehicle control function. ISS will begin operations with contributions from additional international partners. The Canadian Space Station Remote Manipulator System (SSRMS) will be installed on the ISS, and the program used the MPLM from Italy for the first time.

Flight 3A was launched with the Space Shuttle Discovery in October 2000, and included the Integrated Truss Structure Z1, PMA-3, the KU-band communications system, and Control Moment Gyros (CMG's). The first ISS crew, designated Expedition 1, was launched with a Russian Soyuz spacecraft. This began the commencement of permanent human presence in space aboard the ISS. This crew remained aboard the ISS for 4 months before departing. The Soyuz will remain attached to the ISS to provide assured crew return capability without the Shuttle present. Flight 4A, launched with the Space Shuttle Endeavor, delivered the Integrated Truss Structure element P6, a photovoltaic module and two radiators, thereby providing U.S. power and cooling. The S-band communications system will be activated for voice and telemetry.

As each flight adds to the complexity of the Station, the need for analysis of growing maintenance requirements becomes more relevant. In the first quarter of 2000, techniques were developed to predict maintenance backlog and resource requirements for space station. Thus far, 14 planned critical spares have been delivered to orbit, ensuring that the on-board crew has the ability to immediately repair failures that would halt assembly, threaten Station survival or cause the crew to evacuate. In addition, the crew has completed 78 identified maintenance tasks, which included 36 preventive maintenance tasks and 42 corrective maintenance tasks. One such task, completed on Flight 4A, was a design modification to the Solar Array Wing. A robotic interface (Power Data Grapple Fixture) was added to allow a swapout in the event the Wing failed to deploy.

Flight 5A, launched with the Atlantis, carried Destiny, the U.S. Laboratory Module. Destiny was launched with 5 system racks installed. With the delivery of the electronics in the lab, the CMG's are activated, providing electrically powered attitude control. Flight 5A.1, launched aboard the Discovery, ferried the Expedition 2 crew to the station and returned the first crew to earth. It also carried Leonardo, the first Multi-Purpose Logistics Module (MPLM), with equipment racks to outfit the lab module, and the first research rack, HRF #1. A Russian Soyuz rocket will launch the Docking Compartment (DC-1). This will provide additional egress, an ingress location for Russian-based spacewalks, and a Soyuz docking port. Flight 6A, launched aboard the Shuttle Endeavor, will carry Raffaello, the second Italian-built Multi-Purpose Logistics Module (MPLM), including six systems and two storage racks for the U.S. Lab. Also aboard is the UHF antenna to provide space-to-space communications capability for U.S.-based spacewalks, and the Canadian SSRMS (station mechanical arm) required to perform assembly operations on later flights. Flight 7A, launched aboard the Atlantis, will deliver the Joint Airlock and the High Pressure Gas Assembly. The former will provide station-based extravehicular capability for both U.S. and Russian spacesuits, while the latter will support spacewalk operations and augment the Zvezda Service Module gas resupply system. The addition of this hardware completes Phase 2 of the ISS, indicating that it has achieved a certain degree of self-sufficiency and capability without the presence of an orbiter. Flight 7A.1 will use the Shuttle Endeavor to ferry the third resident crew to the station. It would also carry an Italian-built MPLM module containing U.S. stowage racks and International Standard Payload Racks (ISPR's). The second U.S. built spacewalkers' crane will be attached to the exterior of the station.

Expedition 3 has two more training trips to Russia this year and two more trips in the US with their launch in the summer. Expedition 4 is also training in preparation for launch. Last year Expedition crews as well as Shuttle crews were trained at JSC and in Russia. This year Russian Cosmonauts that fly the Soyuz to ISS will train at JSC. The next Expedition crew scheduled to launch on a Soyuz will be the Expedition 5 crew.

Training for Expedition crews 5, 6 and 7 will continue in FY 2001 and is scheduled to be completed in FY 2002. The training template suggests that the crews for Expeditions 8-11 will begin in FY 2001. Space Station Operations will provide real time support to flights 5A.1, 6A, 7A, and 7A.1. IDRD's for planning periods in 2002 and 2003 will be baselined.

The Space Station Training Facility (SSTF) became available to support the ISS mission near real time. Any problems or procedures that the Mission Control Center (MCC) would like to run before having the ISS Expedition crew execute them on orbit can now be performed in the SSTF. Space Station Training Facility will support crew and flight controller training through 8A in FY 2001. MCC-H will support through 5A. Primary real-time ISS vehicle control responsibility was transferred from MCC-M to MCC-H with Flight 5A. MCC-H software loads will be delivered for flights up to UF-2. Standalone Payload Training Capability (PTC) was operational for flight 5A.1; the integrated PTC will be ready for flight UF-3.

FY 2002

FY 2002 will signify the beginning of Phase 3 of the Station Program. For much of 2002 the station will be supplied with experiment and logistics racks, including the first deployable cargo carrier. The major framework of the station will begin to take shape and the arrival of the next three rotating Expedition crews is also planned.

UF-1, the first utilization flight, will be delivered by Atlantis, and will include an MPLM and PV Module Batteries. The MPLM will contain experiment racks for the U.S. Lab and two storage racks. Beginning with Flight 8A the crew will install the Integrated Truss Structure S0 and the Mobile Transporter. The S0 is the center segment of the 91-meter (300-foot) station truss and attaches to the U.S. Lab. The Mobile Transporter will create a movable base for the station's Canadian mechanical arm, allowing it to travel along the station truss after delivery of the Mobile Base System, or MBS. The launch of 4S (Soyuz) will bring the Expedition 5 crew aboard and will be the first return of a departing Expedition crew aboard a Soyuz. The second utilization flight, UF2, provides more experiment racks and three stowage and resupply racks to the station. The Mobile Base System, once installed on the Mobile Transporter, will complete the Canadian Mobile Servicing System, or MSS.

The first starboard truss segment, S1, arrives on Flight 9A. As part of the integrated truss structure, it will house batteries, computers, radiators, antennas, and gyroscopes. 9A will also bring aboard cooling radiators, backup S-band communications, and the Crew and Equipment Translation Aid (CETA) cart that will enable EVA crew to move along the truss with their equipment. The Utilization and Logistics Flight (ULF1) is scheduled to launch in June 2002 and will mark the first flight of a deployable cargo carrier known as the External Stowage Platform (ESP2). ESP2 will be deployed from the Space Shuttle by the Space Station Remote Manipulator System (robotic arm) and attach to the air lock of the ISS as a permanent spare parts stowage facility – a sort of depot in space. It will include a cargo pallet specially outfitted with release mechanisms to permit ORU removal and replacement and cable systems to provide power directly from the ISS to individual payloads. The Expedition 6 crew will also arrive on ULF1.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION RESEARCH

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Research Projects..	246,200	300,353	
Utilization Support..	148,200	157,038	
[Construction of Facilities included]	[3,000]	[--]	
Total..	394,400	457,391	

* FY 2002 funding is currently under review and allocations to Research Projects and Utilization Support will be determined as part of program assessments.

PROGRAM GOALS

NASA will utilize the ISS as an interactive laboratory in space to advance scientific, exploration, engineering and commercial activities. As a microgravity laboratory, the ISS will be used to advance fundamental scientific knowledge, foster new scientific discoveries for the benefit of the U. S., and accelerate the rate at which it develops beneficial applications derived from long-term, space-based research. The ISS will be the world's premier facility for studying the role of gravity on biological, physical and chemical systems. The program will deliver the capability to perform unique, long-duration, space-based research in molecular, cellular, comparative, and developmental biology, human physiology, biotechnology, fluid physics, combustion science, materials science and fundamental physics. The experience and knowledge gained from long-duration human presence on the ISS will help us learn how to more safely and effectively live and work in space. ISS will also provide a unique platform for making observations of the Earth’s surface and atmosphere, the sun and other astronomical objects, as well as the space environment and its effects on new spacecraft technologies.

NASA is in the process of restructuring the research program to better align it with the on-orbit capabilities and fiscal resources available. The results of this review, with preliminary results completed in the next few months, will require adjustments to the research planning. This restructuring activity will be completed no later than September, 2001prior to submission of the FY 2003 budget request to the Office of Management and Budget. In order to ensure that the Space Station budget remains within the President’s five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. In addition, funding for U.S. research equipment and associated support will be aligned with the assembly build-up. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities. The following narrative highlights issues and areas which will be prioritized and restructured over the next few months.

STRATEGY FOR ACHIEVING GOALS

The strategy for obtaining the program's goals for ISS is threefold: 1) complete and deploy the core ISS research facilities and the supporting infrastructure; 2) conduct research during the assembly in a diversified set of disciplines; and 3) facilitate commercial utilization of the space environment.

1) *Complete and deploy the core ISS research facilities and the supporting infrastructure.*

The core of the ISS research program will be the first 10 racks scheduled for deployment including the Human Research Facility Rack 1 and 2, six Express Racks, the Microgravity Sciences Glovebox, and the Window Observational Research Facility.

The remaining major research facilities including the Gravitational Biology Facility, Centrifuge Facility, Materials Science Research Facility, Fluids and Combustion Facility, Biotechnology Facility, and the Low Temperature Microgravity Physics Facility will be built on a priority basis, as fiscal resources are available. The research program hardware will emphasize automation, remote monitoring, real-time feedback, telemanagement and ground commands to maximize utilization opportunities.

NASA is developing the Expedite the Processing of Experiments to Space Station (EXPRESS) racks for the pressurized laboratories, and EXPRESS pallets for the unpressurized environment of the Station to increase the research return from the ISS by raising the overall numbers of payloads through allowing access to the station for investigations and payloads at a sub-rack and sub-pallet level.

The common-use Laboratory Support Equipment such as the Microgravity Science Glovebox, the Life Science Glovebox, the Minus Eighty degree Laboratory Freezer for the ISS (MELFI), and the Cryofreezer will allow quick, simple experiments to be conducted aboard the ISS, as well as support experiments in the other facilities and EXPRESS Racks.

Research Facility Descriptions

These research facilities will be reviewed during the budget restructuring activity and prioritized as part of the program reassessment.

Biomedical research facilities and activities include the Human Research Facility (HRF), the Crew Health Care Subsystem (CHeCS) and associated payload development. The HRF provides an on-orbit laboratory that will enable life science researchers to study and evaluate the physiological, behavioral, and chemical changes in human beings induced by space flight. The HRF consists of two racks, and associated payload equipment. Research performed with the HRF will provide data relevant to long-term adaptation to the space flight environment. Many capabilities developed for the HRF have Earth-based application. HRF hardware will enable the standardized, systematic collection of data from the ISS crewmembers, to conduct basic and applied human research and technology experiments.

In addition to the biomedical research that will be conducted using the HRF, NASA's biomedical activities aboard the ISS will include the suite of hardware necessary to protect crew health. CHeCS will support medical care requirements for the ISS crew following deployment of the U.S. Laboratory module. CheCS hardware will provide inflight capabilities for ambulatory and emergency medical care. It will support monitoring of medically necessary environmental parameters, along with capabilities for counteracting the adverse physiological effects of long-duration space flight. Hardware commonality between CHeCS and the HRF and the synergy between the two programs will result in maximum research efficiency and cost savings.

Supporting the Fundamental Space Biology discipline, the Gravitational Biology Facility includes two Habitat Holding Racks, a Centrifuge Rotor, Life Sciences Glovebox, and two service system racks. This suite of equipment, and associated payloads comprise the world's first complete gravitational biology laboratory in space to provide basic tools to conduct physiological, developmental biology and genetic research on the whole organism and at the cellular level. When completed it will support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, aquatic organisms, insects, higher plants, and rodents. The Gravitational Biology Facility will support specimen sampling and storage as well as limited analysis activities. A modular design will accommodate the incremental development of experiment capabilities in a manner consistent with evolving ground and flight science needs of the international research community.

A centrifuge measuring 2.5 meters in diameter will provide artificial gravity, generating forces ranging from 0.01 g to 2.0 g (i.e., from 1/100 to twice the gravity on Earth). Specially developed "holding racks" in the laboratory will provide electrical power and cooling to plant and animal habitats. Habitats in the holding racks will provide food, water, light, air and waste management as well as humidity and temperature control for a variety of specimens-rats and mice, insects, plants, small aquatic organisms, one-celled organisms, and cell cultures. Under the NASA-NASDA Agreement in Principle, National Space Development Agency of Japan (NASDA) will provide the Centrifuge Rotor, Life Sciences Glovebox and the Centrifuge Accommodation Module.

Microgravity Research flight hardware development includes the Material Science Research Facility, Fluids and Combustion Facility, the Space Acceleration Measurement System (SAMS II) and the Microgravity Acceleration Measurement System (MAMS), Structural Biology Test hardware, Microgravity Sciences Glovebox, Biotechnology Facility, Low-Temperature Microgravity Physics Facility, and associated payload development.

The Space Station Materials Science Research Facility (MSRF) consists of three autonomous racks that will be used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. The research goals of these studies are to establish and improve quantitative and predictive relationships between structure, processing, and properties of metals and alloys, polymers, electronics and photonics, ceramics and glasses, and nano-structured and bio-materials, as well as further the development of materials for human radiation shielding in long-term occupation of space. Many industrial applications from this research apply to metals, microelectronics, metalography, ceramics, agriculture, mining, and forestry. Cooperative efforts are underway with the international science community that will assist in the development of some discipline-specific furnace inserts for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA. The initial configuration of the first rack will contain the Space Product Development Experiment Module (SPDEM) and a European Space Agency (ESA)-developed Experiment Module that can process, and accommodate the exchange of multiple furnace inserts for specific classes of U.S. investigations.. After completion of the commercial investigation, the commercial Experiment Module will be replaced on-orbit with additional NASA-developed Experiment

Modules. The studies performed in the MSRF will also support the Office of Industrial Technologies of the Future (IOF) partnerships with eight U.S. industries.

The Fluids and Combustion Facility (FCF) is a modular, multi-user facility that will accommodate sustained, systematic microgravity experimentation in both the fluid physics and combustion science disciplines. The FCF is a three-rack payload consisting of the Fluids Integrated Rack, the Combustion Integrated Rack, and the Systems Accommodation Rack. The first two of these racks, the CIR and FIR, are incrementally deployed to ISS and operated independently. They are then fully integrated into and operated as the FCF System upon arrival of the Systems Accommodation Rack (SAR). Because of the modularity, capability and flexibility of the FCF System, experiments from science disciplines outside of fluids and combustion, as well as commercial and international payloads, can also be supported by the FCF.

The Combustion Integrated Rack houses a combustion chamber designed to accommodate a variety of experiments or modules to conduct multiple experiments within a given class of investigations. It is equipped with ports to allow an array of modular diagnostic systems to view the experiment. This rack supports investigations with the goal of improving our understanding of combustion processes to help us deal better with the problems of pollutants, atmospheric change and global warming, unwanted fires and explosions, and the incineration of hazardous wastes.

The initial experiment module to fly in the (CIR) will be the Multi-User Droplet Combustion Apparatus (MDCA). The objectives of this experiment apparatus are to improve our understanding of how liquid-fuel droplets ignite, spread, and are extinguished under microgravity conditions. It will accommodate four unique investigations with droplets of various sizes that are either deployed or supported by a tether. Its modular approach permits on-orbit changes to these investigations such as using different fuels, droplet-dispensing needles, and droplet tethering mechanisms. The MDCA will also use a variety of diagnostic measuring techniques that will capture the specific data desired by the PI, including radiometry, soot volume fraction, soot pyrometry, soot sampling and particle imagery.

The Fluids Integrated Rack is designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. It supports investigations to better understand the physical principles governing fluids, including how fluids flow under the influence of energy, such as heat or electricity; how particles and gas bubbles suspended in a fluid interact with and change the properties of the fluid; how fluids interact with solid boundaries; and how fluids change phase, either from fluid to solid or from one fluid phase to another.

The first multi-purpose investigation planned for the FIR is the Light Microscopy Module (LMM). This apparatus is a fully remotely controllable on-orbit microscope, allowing a variety of diagnostic measurements and controls of fluids experiments, and other discipline investigations. Initially four experiments are planned which will investigate heat conductance in microgravity to determine the transport process characteristics in a liquid film, and the complementary aspects of the nucleation, growth, structure and properties of colloidal crystals in microgravity. Key diagnostics under development include video microscopy (to observe basic structures), interferometry (to measure vapor bubble thin film thickness), laser tweezers (to manipulate colloidal particles), confocal microscopy (to provide three dimensional visualization of colloidal structures) and spectrophotometry (to measure crystal photonic properties).

The Systems Accommodations Rack provides common support systems such as data/image processing and power distribution for both the combustion and the fluid integrated racks. Once the SAR is deployed, these common functions will be transferred to it, thus allowing for increased science specific real estate on the CIR and FIR and more science throughout. The SAR will also house stand-alone fluids experiments, as well as experiments from other microgravity disciplines, including international investigations.

The Structural Biology Test hardware is composed of a suite of instruments including the Iterative Biological Crystallization (IBC), Crystal Preparation Prime Item (CPPI) and supporting equipment that will meet the requirements imposed by the recent National Research Council report to fund a series of high-profile grants to support microgravity research to produce crystals of macromolecular assemblies with important implications of cutting-edge biology problems. The Structural Biology Test hardware will emphasize automation, monitoring, real-time feedback, telemanagement, and sample recovery (via mounting and cryogenically freezing). The purpose is to increase the sample iteration throughput and enable qualitative processing changes in a microgravity environment on the ISS.

The Microgravity Science Glovebox (MSG) is a rack that allows crew interaction with an experiment, while providing at least one level of containment for potentially hazardous materials. It will allow small-scale research to be carried out in the various fields of materials science, fluid mechanics, combustion, biotechnology, cell science, and acceleration measurement. The rack provides a work volume for placing the experiment, and an airlock mechanism for transferring items into the work volume without compromising the level of containment. It provides power, data, video, and thermal interfaces to the payload within the work volume. This rack is being developed by ESA through a barter agreement.

The Biotechnology Facility (BTF) is the laboratory component of ISS that hosts basic and applied research in cell science. The BTF is a one rack modular design that uses microgravity conditions to achieve unique goals in the engineering of human tissues for research and transplantation, modeling of human disease (cancer), vaccine and drug development, production of biopharmaceuticals, and space cell biology that supports the exploration of space. NASA-developed bioreactors have already produced the first 80-day lung culture, the first normal human intestine culture, and major breakthroughs in the quality of cancer tumor cultures. Two bioreactor flight experiments on Mir cultured tissues over four-month periods. The BTF will support bioreactor research to address the long-duration aspects of this research.

The Low Temperature Microgravity Physics Facility (LTMPF) attached payload will investigate the fundamental behavior of condensed matter without the complications introduced by gravity and perform high-resolution tests in gravitational physics. Primary LTMPF research will study the universal properties of matter at phase transitions, the dynamics of quantum fluids, and test Einstein's theory of relativity. The LTMPF will be a remotely operated payload package attached to the Japanese Exposed Facility of the Station and is expected to improve measurements by a factor of 100 over similar terrestrial tests. This attached payload facility will support research instruments at a temperature between 0.5 and 4 degrees Kelvin and provide up to 6 to 8 months of microgravity operation between reservicing and hardware changeout.

The Window Observational Research Facility (WORF) will be located in the U.S. Laboratory Module at the nadir- (Earth) pointing window location. The WORF is placed in front of the US Laboratory's 20-inch-diameter research-quality window. This is the highest quality optical window ever flown on a crewed spacecraft. The WORF supports optical equipment for environmental monitoring and Earth observations, as well as viewing of rare and transitory surface and atmospheric phenomena. Operation of the rack and sensor payloads will be performed remotely from the ground, or by the crew.

The Stratospheric Gas and Aerosol Experiment (SAGE III) attached payload will measure chemical properties of the Earth's atmosphere between troposphere and the mesosphere. A key aspect of this research will investigate effects of aerosols on ozone depletion in the atmosphere. SAGE III will be attached outside of the Station on an EXPRESS Pallet. The SAGE III instrument will be mounted on an ESA-provided precision-pointing platform.

As noted, significant progress continues to be made in the establishment of international participation in the provision of U.S. research facilities. The Centrifuge, Centrifuge Accommodation Module, and Life Sciences Glovebox development continue under the Implementing Agreement with the NASDA as partial offset for the Shuttle launch of the JEM. The cryogenic freezer racks and the Minus-Eighty Degree Laboratory Freezer (MELFI) and the Microgravity Science Glovebox (MSG) will be provided by the ESA under a March 1997 Memorandum of Understanding. The Brazilian Space Agency (AEB), as a participant in the NASA program, will provide the EXPRESS Pallet and the Technology Experiment Facility under an Implementing Arrangement between the U.S. and Brazilian governments.

Utilization Support Infrastructure

While many of these utilization support capabilities are already in place to support research during the early assembly sequence, they will be reviewed during the budget restructuring activity and future upgrades and expansions will be prioritized as part of the program reassessment.

In addition to the major facility-class payloads, NASA plans to fly smaller, less complex payloads on the ISS which will typically have more focused research objectives and shorter development time cycles and will be easily adapted to a variety of users. An EXPRESS Rack will enable a simple, streamlined and shortened analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The EXPRESS pallet project provides small-attached payloads with a similar streamlined process and hardware and software interfaces. The Brazilian Space Agency is responsible for developing the EXPRESS pallets for NASA.

Laboratory Support Equipment (LSE) is under development to support Life and Microgravity Sciences and other experiments. This equipment includes a digital thermometer, video camera, passive dosimeter, specimen labeling tools, microscopes, small mass measurement device, pH meter, and an incubator. A cryogenic transport freezer and the Minus Eighty-Degree Laboratory Freezer (MELFI) are also being developed to support ISS research activities.

NASA continues to develop a ground infrastructure to support the deployment and operation of the research on the ISS. These capabilities provide the facilities, systems and personnel to support the ISS user community in efficient and responsive user/payload operations. Support is provided for flight and ground capabilities to ensure efficient and complete end-to-end payload operations. NASA and International Partner payload operations are integrated to ensure efficient, compatible use of ISS payload resources. This infrastructure provides pre-flight payload engineering integration, verification and checkout support, payload operations integration, payload training, mission planning, real-time operations support, data processing and distribution and launch site support. Services begin with initial definition of the payload for flight and continue throughout onboard ISS operation and return of experiment's data and equipment to the user. Services include documentation of interfaces and verification requirements, training of ground and flight teams, and development and execution of mission plans to meet the needs of the user community.

The Payload Operations and Integration Center (POIC) is a facility that manages the execution of on-orbit ISS payloads and payload support systems in coordination with the Mission Control Center in Houston (MCC-H), the distributed International Partner Payload Control Centers, Telescience Support Centers and payload-unique facilities. The POIC is established and managed by NASA to provide ISS overall integration of payload planning and coordination of on-orbit payload activity execution. It provides a single point of contact between the MCC-H and all utilization activity. In this capacity, the POIC manages payload resource usage, vehicle support system configuration, space-to-ground communications, and overall payload safety operations. To support operations, the POIC Cadre produces a number of operations products based on payload developer submitted data including: flight rules, payload regulations, payload On-orbit Summaries (operations plans), payload procedures, payload computer displays, training lessons/plans, simulation scripts, payload operations handbook, payload ground command procedures, payload systems manuals, console handbooks, data/video plans, command plans, and data flow plans.

The heart of the POIC capability is the Enhanced Huntsville Operations Support Center (HOSC) System (EHS) software. Under development by Lockheed-Martin, this software package coupled with commercial computing systems provides the capability to build, process and transmit commands to the on-orbit payloads, decommutate and route payload telemetry, uplink, downlink and transfer files, record and store telemetry, store and display payload procedures, and a whole host of other functions required for control center operations.

The external interfaces of the POIC include voice, video and data via the NASA Integrated Services Network (NISN) network to the MCC-H, KSC, White Sands, the Telescience Support Centers (TCS), the International Partner control centers and remote payload investigator home sites (such as universities). Voice and file transfer circuits have been activated to MCC-H, Mission Control Center-Moscow (MCC-M), and the Johnson Space Center and Glenn Research Center TSC's.

Key to the implementation of research aboard the ISS is the ability to control a payload from the researcher's laboratory. To implement this NASA has developed the Telescience Resource Kit (TReK). The TReK is a PC-based, low-cost (approximately $10K) telemetry and command system that will be used by scientists and engineers to monitor and control experiments located on-board the ISS. A TReK system can be located anywhere in the world. This provides a way for scientists and engineers to monitor and control their experiments located in space from their offices and laboratories at home.

In addition to the TReK, NASA is building Telescience Support Centers in strategic locations--Johnson Space Center, Marshall Space Flight Center, Ames Research Center, and Glenn Research Center--to support local operation of EXPRESS Racks and facility-class payloads. These Telescience Support Centers provide significantly more capability for interaction with a rack than does the TReK. The facility operators can manage all functions of their rack, while interacting remotely via TReK with the Principal Investigators, to monitor and control the command and telemetry of the investigation on ISS.

The Payload Planning System (PPS) is a key element of ISS payload planning and execution. It provides unique science operations support and scheduling capabilities not available in the Consolidated Planning System (CPS) employed Johnson Space Center for ISS systems and overall operations integration while still utilizing many core CPS capabilities. Examples of unique PPS capabilities include: flexible schedule adjustment as scientific results are obtained, while remaining within the resource constraints defined by the MCC-H; ability to plan payload operations that allow the payload developer to segment and combine science procedures for both repetitive and unique sequences; and integrated management of ISS resources (power, thermal, bandwidth, crew time, etc.) allocated to payloads.

The Payload Data Library (PDL) is an Oracle-based relational database that provides the prime data collection and storage capability for pre-flight payload integration for the Payload Developers. PDL provides each payload developer with a web-based interface to electronically submit Payload Integration Agreement (PIA) data supporting tactical planning as well as Interface Control Document (ICD) and Payload Data Set submissions that comprise the raw material for flight-specific operations product development.

NASA has developed a distributed approach to verification of ISS interfaces prior to flight through the development and deployment of Payload Rack Checkout Units (PRCU) and Suitcase Test Environments for Payloads (STEP) test tools.

The STEP provides simulation of ISS-to-Payload data system interfaces. It is portable and designed for use at payload development sites, early in the software and data systems design cycles. The STEP allows the developer to test software and communication protocols against a common standard during development in order to optimize design solutions and minimize errors late in the development cycle. This distributed approach to verification testing allows for identification and resolution of most problems prior to sending the payload to Kennedy Space Center for final functional test before flight. In addition to interface verification, STEPs are being utilized for crew training by providing high fidelity ISS data simulation for payload rack training units.

The Payload Test and Checkout System (PTCS) is the ground system at Kennedy Space Center in which final verification for flight is performed. The PRCU simulates all ISS-to-Payload Rack power, data, and fluids interfaces, providing capability for development and verification testing of payload racks at the sites where they are being built and/or integrated. In this test system, final rack and experiment level checkout is performed utilizing actual flight and ground system software and high fidelity ISS Flight Equivalent Units. The PTCS also allows integrated testing of racks with a Payload Operations Integration Facility workstation, identical to what experimenters will see on-orbit, emulating a close loop test.

The Space Station Processing Facility at Kennedy Space Center will accommodate the majority of the research facility and experiment launch site processing. In addition, the Space Experiment Research and Processing Laboratory (SERPL) is being built at Kennedy Space Center as a partnering effort with the State of Florida to accommodate pre- and post- launch biological and life science experiment processing. SERPL will replace the existing Hanger L specialized science processing facility at KSC, providing state-of-the-art animal care facilities, general experiment processing and integration labs, ground control capabilities, and flight experiment processing. Areas include Biotechnology, Microgravity, Space Agriculture, Biomedicine, Conservation Biology, and Microbial Ecology. The facility is envisioned to be a magnet facility in a potential Space Station Commerce Park at Kennedy Space Center. This potential project would also be a product of close teamwork between NASA and the State of Florida, and would represent an opportunity to enhance commercial and academic access to the spaceport and International Space Station.

2) *Conduct research during assembly in a diversified set of disciplines.*

The second major strategy is to conduct research beginning during the early assembly period. To maintain the viability of NASA's priority research programs, the ISS must support a range of disciplines during assembly. The research strategy must develop and take advantage of as many flight opportunities as possible.

The Research Program is poised to take advantage of available flight opportunities to the ISS. Resources are available to deliver rack level hardware on many of the utilization and assembly flights throughout the assembly process. Middeck locker level experiments and logistics resupply will be available on most utilization and assembly flights in the Shuttle middeck and Multi-Purpose Logistics Module (MPLM).

The Rev. F Assembly sequence added flights ULF1 and 13A.1. ULF1 offers the opportunity to deploy racks earlier than previously planned, and flight 13A.1 offers the opportunity to deliver additional middeck and sub-rack level research hardware. Flights 5A.1 through ULF1 enable NASA to deploy the first 10 research racks to orbit. These 10 racks represent the core of NASA's total planned rack level outfitting. The 10 racks include two Human Research Facilities (HRF), six EXPRESS racks, Microgravity Science Glovebox (MSG), and the Window Observational Facility (WORF).

Delivery of the Human Research Facilities (HRF) and EXPRESS racks aboard the ISS early in assembly will allow deployment of payloads supporting many disciplines. The HRF will facilitate early research in the life sciences discipline. The EXPRESS rack program will provide valuable flight opportunities for middeck locker scale experiments and product development in the areas of fundamental biology, biotechnology, biomedical sciences, fluid dynamics and combustion research.

The Microgravity Science Glovebox will allow small-scale research to be carried out in the various fields of materials science, fluid mechanics, combustion, biotechnology, cell science, and acceleration measurement. Research can be conducted delivered to this rack on a frequent basis, advancing a broad range of areas.

Even prior to the delivery of the Window Observational Research Facility (WORF), Earth observations will be conducted through the research-quality window in the US Laboratory. With the delivery of WORF, NASA will position the Earth science discipline to take advantage of the unique opportunities available on the ISS.

The revised Assembly Sequence also opened the opportunity to utilize the attached payload sites on the truss as early as possible. The Alpha Magnetic Spectrometer is currently scheduled for flight UF4, which moved up in the assembly sequence significantly.

As further refinement of resource availability and flight opportunities continue, the racks delivered early in the assembly sequence will be postured to take advantage of these resources. Delivery of future research facilities will continue to closely track the buildup of ISS accommodations to ensure the research programs ramp up as soon as capability becomes available. The research program will continue to be aligned with the availability of on-orbit resources, including crew time, power and upmass capabilities.

3) *Facilitate the commercial utilization of the space environment.*

The stage has been clearly set for commercialization of space. NASA continues to reserve 30% of the resources for commercial development of space. NASA and Congressional activities in 1999 facilitated the environment for accelerated commercial development of space, and commercial agreements have already been implemented for use of some of the reserved resources.

NASA has signed an agreement with Dreamtime Holdings, Inc., for multimedia services across NASA. Preparations are underway to fly a High Definition TV camera aboard the ISS. Volume on flight 7A.1 has been reserved for this camera and associated hardware. The camera qualification is underway. Within the bounds of the agreement, this flight will be the first of many for Dreamtime equipment aboard the Shuttle and ISS.

NASA also recently signed an agreement with SkyCorp, Inc. to deploy a developmental test of a satellite via a crewmember EVA. The satellite will be based on a G4 Macintosh server, and be an Internet server deployed in space. The concept behind this type of deployment may dramatically reduce costs of satellite deployment by reducing redundancy requirements, structure requirements for ELV launch, and by providing a checkout by a crewmember prior to deployment. Currently, schedules for SkyCorp's development cycle are under review.

NASA's commercial research programs for ISS will take advantage of the new opportunities for space flight operations provided by the ISS, and a distinctly new operating environment. Among other activities, the commercial research programs for the ISS will concentrate on commercial protein crystal growth, antibiotic production, and plant growth research. The commercial protein crystal growth activities for ISS are underway at the Center for Biophysical Sciences and Engineering, the plant growth research at the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates.

NASA is also continuing to study options for creating a Non-Government Organization (NGO) to manage ISS utilization and commercial development. The National Research Council formed a "Task Group on Institutional Arrangements for Space Station Research" and delivered a report in December 1999, which generally supported the NGO concept. The Office of Space Flight also commissioned an "ISS Operations Architecture Study" which delivered a report in August 2000 also supporting the NGO concept to "improve management of user interface and enhance ISS productivity". A NASA internal study is ongoing to document the utilization functions, evolutionary options and total cost projections. A final report will be delivered to NASA management with decisions expected in FY 2001. Procurement activities may also be initiated in FY 2001.

<u>SCHEDULE & OUTPUTS</u> - The project schedules will be reviewed during the restructuring activity and adjusted as part of the program reassessment.

Research Projects

Centrifuge & Life Sciences Glovebox CDR Plan: Rotor 3rd Qtr FY 2001 LSG 4th Qtr FY 2001 Revised: TBD	The Life Sciences Glovebox (LSG) PDR was completed during early FY2000.
Fluids & Combustion Facility (FCF) FCF System PDR Plan: 4th Qtr FY 2000 Revised: 2nd Qtr FY 2001	The FCF System PDR was initiated in 1st Qtr. 2001 and will be concluded in 2nd Qtr. FY2001.
FCF Combustion Integrated Rack (CIR) CDR Plan: TBD	
Materials Science Research Facility Rack 1 CDR Plan: 4th Qtr FY 2000 Revised: TBD	The MSRF PDR was completed during FY2000.
Materials Science Research Facility Rack 2 CDR Plan: 4th Qtr FY 2000 Revised: 1st Qtr FY 2003 Revised: TBD	
Human Research Facility Rack 2 CDR Plan: 4th Qtr FY 2001	The HRF Rack 2 will complete a CDR in late FY2001 and begin Fabrication/Testing during FY2002.

Gravitational Biology Facility
Rack 1 Fab/Assy/Test
Plan: 4th Qtr FY 2000
Revised: TBD

Biotechnology Facility PDR
Plan: 3rd Qtr FY 2000
Revised: 3rd Qtr FY 2001
Revised: TBD

Low Temperature Microgravity Physics Facility PDR
Plan: 2nd Qtr FY 2000
Actual: 4th Qtr FY 2000

Utilization Support

EXPRESS Racks 1 & 2 Final Testing and Reviews Plan: 2nd Qtr FY 2000 Actual: 1st Qtr FY 2001	The first two EXPRESS Racks are at KSC undergoing final testing and subrack integration in preparation for launch on 6A.
Complete POIC/USOC and facilities outfitting Plan: 1st Qtr FY 2000 Actual: 1st Qtr FY 2000	The Payload Operations Integration Center (POIC) and U.S. Operations Center (USOC) at MSFC completed hardware installation and checkout during early FY 2000.
EXPRESS Pallet PDR Plan: 4th Qtr FY 1999 Revised: 1st Qtr FY 2001	The EXPRESS Pallet PDR is planned to begin in early FY2001. Brazil continues to experience ongoing funding problems with the Pallet.
WORF Block 1 CDR Plan: 2nd Qtr FY2000 Actual: 2nd Qtr FY2000	The Window Observational Research Facility (WORF) completed its CDR in mid FY2000.

Communications Link Activation Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	The initial communication link activation from the Huntsville Operations Support Center (HOSC) to the Space Station Control Center (SSCC) to support payload training and operations occurred during late FY 1999. Full communication link activation occurred in FY 2000.
PPS Build 3 Plan: 1st Qtr FY 2000 Actual: 2nd Qtr FY 2000	The Payload Planning System (PPS) capabilities required to support Cadre-Payload Developer Training was completed during mid 2000. Build 3 was completed in FY2000.

ACCOMPLISHMENTS AND PLANS

Research Projects - FY 2000

On-orbit research on the ISS has begun, even with the limited resources available at this point in the assembly sequence.

The Commercial Generic Bioprocessing Apparatus (CGBA) was launched and returned on flight 2A.2B. This commercially developed payload housed experiments from Yale University and Tulane University. In part based on this successful flight, Tulane, NASA and Fisk Ventures, Inc. signed a partially exclusive license agreement to allow commercial use of NASA's bioreactor for ground-based research, potentially leading to further flight-based studies on the ISS.

The Protein Crystal Growth-Enhanced Gaseous Nitrogen Dewar (PCG-EGN) was the first long-duration experiment on ISS. It was launched aboard flight 2A.2B, and the experiment and its samples were returned to Earth on flight 3A. Proteins were crystallized in this Dewar for analysis in laboratories on the ground. Notable for this payload is the connection to middle and high schools in several states. The Principal Investigator has worked with numerous middle and high school science teachers and students to train them in aspects of protein crystallization, allowing students to prepare samples that ultimately were flown aboard this payload. The samples were returned to the high schools for analysis. The Dewar will be flown, with different protein samples on flights 5A and 5A.1.

The Middeck Active Control Experiment (MACE-II) is a payload sponsored through an interagency agreement by the Department of Defense. The payload tests critical elements of satellite control by actively damping vibrations of a large structure. This payload was launched aboard flight 2A.2B, and placed aboard the ISS for operation by the first ISS Expedition crew.

These first experiments all went from identification of flight opportunity, through the analytical integration process, to flight in eight months. While the sheer number of future experiments will preclude a compressed schedule for all payloads, this shortened integration process addresses a long-standing concern showing that NASA is capable of integrating and flying experiments on short notice.

Numerous additional experiments are being actively prepared for the first few ISS increments, including payloads in human life sciences, fundamental biology, structural biology, education, Earth observation, cell biology, fluid physics and materials processing as well as a number of commercial activities. Members of the first five Expeditions have undergone training or continue to be trained on payload activities.

Technical Interchange Meetings were held with Dreamtime and SkyCorp payload developers in preparation for launch. These are the first two commercial (reimbursable) payloads manifested for the ISS.

The first ISS research rack, the Human Research Facility (HRF), completed final integration and test at Kennedy Space Center. The HRF and sub-rack payloads are integrated into the Multi-Purpose Logistics Module (MPLM) in preparation for launch on 5A.1.

EXPRESS Racks 1 and 2 continued final testing and began integration into the MPLM in preparation for launch on 6A. EXPRESS Racks 4 and 5 are in final integration and testing in preparation for delivery to KSC in mid FY2001.

The Human Research Facility prototype rack and EXPRESS Rack 1, with all subrack payloads incorporated, were successfully installed into the U.S. Laboratory for the Integrated Compatibility Test. This test verified successful operation of multiple racks in a “day-in-the-life” type environment inside the U.S. Lab.

The Microgravity Science Glovebox is in final integration and test in preparation for delivery to KSC in mid 2001 for launch on UF2. A training unit was delivered to Johnson Space Center in late FY2000 to support crew training.

The Biotechnology and Fluid Physics subrack payloads completed their CDRs in mid FY 2000 in preparation for launch on 7A.1.

The Human Research Facility Rack 2 continued in detailed design in preparation for launch on ULF1.

The Program also continued development activities on the remaining facility-class and subrack level payloads.

Much of Gravitation Biology Facility hardware is under development. The Avian Development Facility and Biomass Production System continued fabrication and test in preparation for launch on 8A. The Habitat Holding Rack #1 is in fabrication in preparation for launch on UF3. The Insect Habitat completed a PDR mid FY 2000. The Incubator completed a CDR early FY 2001.

The Life Sciences Glovebox conducted a PDR in early FY 2000 and will initiate a delta PDR in early FY 2001. The Centrifuge Rotor initiated a PDR in late FY 2000 and will continue with a delta PDR into FY 2001. The Glovebox and Rotor will continue in detailed design in preparation for launch late in the assembly sequence.

The Microgravity Science Research Facility Rack 1 completed a PDR in mid-FY2000. NASA and ESA each completed preliminary designs of the first inserts in FY 2000.

The Fluids Integrated Rack and Combustion Integrated Rack of the Fluids and Combustion Facility continued with preliminary design, defining requirements and interfaces with both the ISS, as well as with its unique science modules. The Multi-User Droplet Combustion Apparatus (MDCA) hardware concepts and requirements definition continue in concert with the four investigations identified to conduct operations in the CIR. The Light Microscopy Module and its four investigations also continue to define concepts, requirements, and interfaces with FIR.

Early utilization payloads provided from GRC include the Physics of Colloids in Space (PCS), Space Acceleration Measurement System (SAMS II) and the Microgravity Acceleration Measurement System (MAMS). Each completed development, integration and testing with the EXPRESS Rack at KSC and are ready for launch and ISS on-orbit operations commencing with Flight 6A.

The Low Temperature Microgravity Physics Facility completed a CDR and continued working through formulation phase in FY 2000. LTMPF initiated discussion with NASDA to resolve issues pertaining to payloads using the Japanese Experiment Module-Exposed Facility.

The SAGE III attached payload completed an instrument CDR and continued in assembly and test in FY 2000. The Hexapod Pointing Platform, which will be provided under the ESA Early Utilization Agreement, will continue in detailed design.

The Alpha Magnetic Spectrometer attached payload completed a PDR in mid-FY2000 and continued in detailed design.

The WORF Rack completed a CDR in mid-FY2000. Hardware fabrication and integration has begun for the flight rack, as well as for a ground rack (for payload development and testing) and a trainer rack (for crew training and ground troubleshooting).

Research Projects - FY 2001

The MACE-II payload and three additional crew and education payloads were operated in the early weeks of the first Crew Increment. These additional payloads include the Crew Earth Observation camera, the Earth Knowledge Acquired by Middle School (EarthKAM) camera and the Education-Space Exposed Experiment Developed for Students (SEEDs) experiment.

The Program will maximize early research opportunities on the Human Research Facility (HRF) Rack 1 and EXPRESS Racks scheduled for delivery to the ISS in early FY2001.

The HRF was launched on 5A.1. Following on-orbit rack checkout and test, research operations will be initiated in the areas of radiation monitoring, medical research and care, bone and muscle studies, psychosocial studies, pulmonary function, and renal stone formation. Human Research Facility research equipment will include the Bonner Ball Neutron Detector (BBND), Active and Passive Dosimeters, Dosimetric mapping (DOSMAP), Phantom Torso Reflex Experimental Kit.

The first two EXPRESS Racks will be launched on flight 6A. EXPRESS Rack level ISS research operations will begin following on-orbit rack level checkout and test. Some of the early sub-rack level payloads will include the Physics of Colloids in Space, Advanced Astroculture, Commercial Generic Bioprocessing Apparatus, Protein Crystal Growth-Single Thermal Enclosure, Commercial Protein Crystal Growth-High Density, Space Acceleration Measurement System-II, Microgravity Acceleration Measurement System, Dynamically Controlled Protein Crystal Growth, Advance Protein Crystallization Facility, Zeolite Crystal Growth, Advanced Protein Crystallization Facility, Space Drums, Biotechnology Cell Science Stowage, Biotechnology Refrigerator, Biospecimen Temperature Controller, and Gas Supply Module.

EXPRESS Rack 2 will be the first Active Rack Isolation System (ARIS) rack. The ARIS was designed to isolate selected racks from ISS vibrations while holding the racks in place in their rack bays. An experiment in EXPRESS Rack 2 will characterize the performance of the ARIS system and provide valuable data for microgravity experiments on later flights.

Near-term work in 2001 will include flight processing of EXPRESS Racks 3, 4, and 5 and their sub-rack payloads, and the Microgravity Science Glovebox.

EXPRESS Racks 4 and 5 will be delivered to KSC in early FY 2001 in preparation for launch on 7A.1. EXPRESS Rack 3 is in final integration and testing in preparation for delivery to KSC in late FY2001 and launch on UF2.

Biotechnology and Fluid Physics subrack payloads will complete final testing and integration in preparation for on-orbit operations in the EXPRESS Racks. They will continue and extend investigations begun on Shuttle missions into the growth and development of mammalian tissue culture and the exploration into the physics and properties of colloids in microgravity.

The Microgravity Sciences Glovebox will be delivered to KSC in mid-FY2001 in preparation for launch on UF2. CSLM continues fabrication, assembly and test in FY2001 and will conduct a Pre-Ship Review (PSR) in the 4th Qtr. FY2001 and 1st Qtr. FY2001 in preparation for launches on ULF1, 11A and 12A.

The Alpha Magnetic Spectrometer attached payload will complete a CDR in mid FY2001. Fabrication will also begin in FY2001.

WORF Rack fabrication, integrated hardware and software testing, and crew training will continue throughout FY2001 with a delivery of the flight unit to the Kennedy Space Center in early FY2002. Sub-rack payload development for WORF continues.

The EXPRESS Pallet PDR is planned for early FY2001. NASA continues to work with Brazil towards resolution of funding issues for their planned EXPRESS pallet contributions.

Development activities on the remaining research facilities will be reviewed during the budget restructuring activity and the facilities will be built in a priority order as fiscal resources are available.

Research Projects – FY 2002

Research projects plans for FY 2002 will be defined as part of the program reassessment

The Human Research Facility and first four EXPRESS Racks will continue on-orbit operations. The Microgravity Sciences Glovebox will complete final integration and test in preparation for launch on UF2. Both racks will initiate research operations following on-orbit rack level checkout and test.

EXPRESS Rack 3, WORF and the Human Research Facility Rack 2 will complete final test and integration in preparation for launch on UF2 and ULF1. The three racks will initiate research operations following on-orbit rack level checkout and test.

Flights UF1, UF2, and ULF1, scheduled for FY 2002, will be the first utilization flights focused on maximizing research opportunities. These flights will continue to deliver research racks and provide middeck and MPLM upmass and volume to support research resupply requirements.

Biotechnology and Fluid Physics subrack payloads will continue on-orbit operations in the EXPRESS Racks. The subracks include the Single-Locker Thermal Enclosure (STES), Dynamically Controlled Protein Crystal Growth (DCPCG) and Enhanced Gaseous Nitrogen (EGN) for the Biotechnology field to carry out crystal growth experiment on medically important macromolecular materials, and Physics of Colloids in Space (PCS and PCS Plus) used to perform experiments for studying the processes of crystal formation.

The Alpha Magnetic Spectrometer attached payload will continue fabrication/assembly/test in FY2001 in preparation for launch.

Development activities on the remaining research facilities will be reviewed during the budget restructuring activity and the facilities will be built in a priority order as fiscal resources are available.

Utilization Support Infrastructure – FY 2000

This past year, many accomplishments were made in the preparation and conduct of crew training for US payloads. Training requirements for each payload manifested on the early increments were established through a series of Training Strategy Team meetings. Development and verification of lesson plans, courseware, training mockups and simulators, and crew procedures and displays were successfully accomplished. Training for the Increment 2 and 3 prime crews and backup crews were conducted at JSC training facilities and received excellent evaluations from the Astronaut Office. Increment 2 payload training is complete; Increment 3 payload crew training is 75% complete.

Many payload operations support capabilities were delivered and tested in preparation to support payload operations beginning in FY 2001. Training for the Expedition Crews for the first four Increments and ground support personnel training continued in preparation for research operations in FY 2001.

The first Payloads Logistics Conference was conducted to support logistics planning and implementation.

The POIC facility completed its hardware installation and checkout in FY 2000. The POIC is currently providing off-line planning support to current onboard payloads and the Increment 1 crew launched on Oct 31, 2000. In addition, initial operations interface work such as Joint Operation Interface Procedures (JOIP's) have been accomplished with Mission Control Center - Houston and Mission Control Center - Moscow. Operations interface coordination is in progress and will continue over the next year with Japan, ESA, Italy, and Canada. Planning, training and operations product development for Increments 2 and 3 has been in progress since FY 1999, Increments 4 and 5 began in FY 2000.

Requirements and course development for Ground Support Personnel (GSP) training was accomplished this pass year. Certification criteria for each position (both POIF cadre and Payload Developer) that will sit on console during an increment were established and baselined. Training processes, curriculums, and flows were also baselined. Course development by subject matter experts was completed and verified and training was begun.

Simulations to date have included POIC Cadre only simulations, Cadre to Telescience Support Center/Remote Payload Investigator simulations, and a voice protocol with the MCC-H. To help prepare the Utilization community for ISS operations, the POIC Cadre has conducted eight Payload Operations Integration Working Group (POIWG) face-to-face meetings between the POIC staff and the Payload Investigators (PI's) to discuss the POIC processes and procedures over the last two years.

Cadre and Payload Developer training for Increments 2, 3, and 4 are currently underway. Training for Payload Developers is done remotely, requiring no travel.

The HOSC Integrated Support Team (IST) supports the POIC facility. The IST provides building, workstation, network and software support for both simulation and real-time operations. IST staffing has completed approximately 80% of its training requirements and will complete 5A-required training in early FY 2001.

The PPS currently is comprised of five major subsystems and is 80% complete. PPS already offers the capabilities needed to support the limited payload operations planned during early ISS assembly, as well as functions required to support planning and integration of later payloads. One of the key features in use today is the capability to exchange planning data with the system operations planners at JSC, as well as the International Partner planners in Russia, Europe, Japan and Canada.

The TReK project successfully completed its Operations Readiness Review in mid FY 2000. Release 1.0 of this software was produced in-house at the MSFC. TReK systems are currently in use for Cadre-Payload Developer simulation training in preparation for Increment 2.

Data circuits for Telescience Support Centers (TSC) have been activated to Boeing Seattle, University of Wisconsin, University of Alabama-Birmingham, University of Colorado and Harvard University all in support of Increment 2 payload operations. Remote site video will be broadcast via satellite to the CONUS and received via 0.9-meter dish at each site and 2 meter dish at each TSC.

Delivery of Payload Rack Checkout Units to Kennedy Space Center and Glenn Research Center was accomplished in 2000, bringing to four the number of units currently operational at NASA Centers.

The final two STEP production units were delivered in early FY2000, bringing the total complement to 13 units, which are currently deployed around the U.S. and also in Europe.

A Preliminary Engineering Review for Science Experiment Research Laboratory (SERPL) was completed.

The Payload Software and Verification Facility was brought on-line this year and has been used to develop flight software products for the 5A.1 and 6A missions. In addition, software products were delivered for the Multi-Element Integrated Test and Integrated Compatibility tests with the U.S. Lab.

The EHS software development is packaged into a series of builds that bring on increasing amounts of capability as required to support an increasingly complex onboard payload complement. Build 4.1, representing a system total of 4.1 million software lines of code (SLOC), was completed and deployed in FY 2000 to support early facility testing. The POIC successfully transmitted payload commands to the ISS Systems Integration Laboratory and to KSC last year to confirm system functionality. The 4.2 build series will bring the SLOC total to 4.2 million and provides capability up to Increment 5. Build 4.2-7.3 comprises the functions necessary to support full POIC support for ISS Increment 2 through 5A.1.

The Payload Data Library currently contains data submissions from 88 payloads/investigations to support preflight integration of manifested payloads. Future PDL software development will include the incorporation of additional payload integration documentation into electronic format, data import/export capability, electronic configuration management and International Partner interfaces.

<u>Utilization Support Infrastructure – FY 2001</u>

Utilization support plans will be defined as part of the program reassessment

Payload operations support capabilities will continue to be delivered and tested in preparation to support on-orbit payload operations beginning in FY 2001. Training for the Expedition Crews and ground support personnel training will continue in preparation for research operations.

The first operation of the Telescience Support Centers (TSC) will occur in mid-FY2001 with launch of the Human Research Facility and EXPRESS Racks 1 and 2 containing several microgravity investigations. Telescience operations of these payloads will be conducted from the JSC and GRC TSCs, with remote operations via TReK to the Principal Investigations (e.g., PCS Investigator Professor Weitz at Harvard University).

The POIC will begin full operational support at flight 5A.1, the start of Increment 2. Planning, training and operations product development for Increments 6 and 7 will commence in FY2001. The POIC is continuing to provide off-line planning support to current onboard payloads and the Increment 1 crew launched on October 31, 2000.

Cadre and Payload Developer training will continue in FY2001 for later increments. In FY2001 we will also begin closer dialog with the International partners regarding the interface training necessary for the ground control centers to operate effectively together.

Crew training requirements, development and verification phase for a number of facility and subrack payloads will continue in FY2001. This will be an ongoing process as new payloads are identified and manifested. In addition training for the Increment 2 and 3 crews will be completed and training for subsequent crews will begin.

Payload Joint Integrated Simulations, which include MCC-H, MCC-M, SSTF/Crew and the POIC/TSC/Remote Payload Investigators, will commence in early FY 2001 and continue up until Increment 2 launch. In addition, subsequent Increment training will commence and overlap previous Increments' training. The POIC Cadre team for early Increments is comprised of 14 controllers. Five teams will rotate (not all shifts fully staffed) to provide 24 x 7 support for on-orbit operations beginning on 5A.1.

Cadre team size will expand to 19 at Assembly Complete to support the full onboard payload complement of 37 International Standard Payload Racks.

The HOSC Integrated Support Team will complete flight 5A required training in early FY2001.

The POIC video distribution satellite transponder service will come online in early FY2001. To reduce network costs, the program is developing voice over the Internet software to enable eight multiplexed voice channels to be streamed via the Internet to as many as 500 Remote Payload Investigators (RPI) eliminating the need for a separate voice instrument and dedicated circuit to each RPI site. This software is planned for completion in early FY2001 with an Operations Readiness Review scheduled in mid FY2001.

The current baseline Ku-Band communication data rate for the ISS ground facilities is 50 Mbps. The onboard Ku-Band system is capable of transmitting at 150 Mbps. The CSOC contractor (Lockheed) has been funded to provide a Subsystem Functional Design Review (SSFDR) of an enhancement of the ground segment to the 150 Mbps rate. The SSFDR is schedule for completion in early FY2001. At that point the ISSP will decide whether to proceed with implementation or shelf the design. A current communication usage study shows that the onboard payload complement will exceed the baseline bandwidth capability at UF-5 (2005).

The EHS Software build 4.2-7.3 is currently scheduled for build ready in early FY 2001, followed by POIC Operations Readiness Review. Build 4.2-10 will support flight 7A.1 and be operational in FY2001. Build 5.0 provides remote commanding capability to geographically separated scientists and two-year telemetry storage. It is required to support flight 9A (Increment 7) is scheduled to be delivered to the POIC for testing in FY2001. Build 5.0 represents a facility total of 4.5 million SLOC and approximately 97% of the total planned software development of the POIC core functions.

TReK Release 2.0 is planned for deployment in FY2001. This release will enable remote usage of enhancements in EHS Build 5.0.

In FY2001 and beyond, capability will be added to Payload Test and Checkout System and Payload Rack Checkout Units (PTCS/PRCU) to test external payloads.

The Payload Planning System final delivery of operational code is planned for early FY2001. PPS already offers the capabilities needed to support the limited payload operations planned during early ISS assembly, as well as functions required to support planning and integration of later payloads.

Utilization Support Infrastructure – FY 2002

Payload operations facilities will continue to support on-orbit payload operations. Payload crew training will continue to support later increments.

On-orbit operation of five payload racks (HRF-1, EXPRESS 1, 2, 4, and 5) will continue in FY2002.

EXPRESS rack 3 will complete processing at KSC and will launch on UF-2 in FY2002.

Future upgrades and expansions of the utilization support capabilities will be reviewed during the budget restructuring activity and prioritized and completed as fiscal resources are available.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION RUSSIAN PROGRAM ASSURANCE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Russian Program Assurance...	200,000	24,040	
[Construction of Facilities included]	[1,000]	[--]	

* FY 2002 funding is currently under review and allocations to RPA will be determined as part of program assessments.

PROGRAM GOALS

NASA's approach to contingency planning is to incrementally fund only those activities that permit the United States to continue to move forward should the planned contributions of our ISS partners not be delivered as scheduled, rather than to assume the responsibilities of other ISS partners. It is a process based on: 1) identification of risks; 2) development of contingency plans to reduce these risks; 3) establishment of decision milestones and the criteria by which action will be taken; and, 4) implementation of contingencies as necessary. The RPA funding provides contingency activities to address ISS program requirements resulting from potential delays or shortfalls on the part of Russia in meeting its commitments to the ISS program, allowing the U.S to move forward with ISS assembly or operations in spite of potential shortfalls. These contingency activities are not intended to protect against the complete loss of Russian contributions. That impact would cause an extended delay to the program, necessitating additional crew return, life support, reboost, and guidance and control capabilities to replace planned Russian contributions, and result in a significantly more costly and less robust space station.

BACKGROUND

For several years Russia experienced significant economic challenges resulting in the Russian Aviation and Space Agency (Rosaviakosmos) receiving only a fraction of its approved budget. These shortfalls resulted in schedule slips of the ISS hardware and operations support that Russia was responsible for funding and providing. To accommodate this shortfall, the U.S. developed a three step contingency plan and initiated specific developments to protect the ISS schedule and capabilities in the event of further Russian delays or shortfalls. In spring 1997, NASA embarked on the initial steps of a contingency plan to provide U.S. capabilities to mitigate the impact of further Russian delays. Step one consisted primarily of the development of an Interim Control Module (ICM), built by the U.S. Naval Research Laboratory for NASA, to provide command, attitude control, and reboost functions to provide a backup capability in the event the Russian Service Module was significantly delayed or not successfully provided. Over the next year further delays continued on the Russian elements. During summer 1998, NASA initiated activities to implement additional contingency plans to provide flexibility for the United States in the event of further Russian delays or shortfalls. These consisted primarily of development of a U.S. Propulsion Module, enhancing logistics capabilities, modifying the Shuttle fleet for enhanced Shuttle reboost of ISS, and procurement of needed Russian goods and services to support Russian schedules for the Service Module and early ISS Progress and Soyuz launches.

STRATEGY

With the successful deployment of the Russian Service Module, and Russia's recent positive performance overall, NASA has reassessed its contingency plans, and determined that much of the Russian assurance efforts were no longer a priority relative to other program needs. Based on the increasing costs to planned RPA elements and the baseline program, and the reduced impact of future Russian non-performance, NASA placed the ICM in "call-up" mode in FY 2000. The ICM is stored at the Naval Research Lab awaiting final disposition. In FY 2001, the Propulsion Module Project was ended, and most RPA funds were transferred to the Vehicle program. Remaining FY 2001 funds are reserved for changes, including the potential procurement of safety-related Russian goods and services. Decisions to implement the remainder of the RPA Program, or to request that remaining funds be reprogrammed to support baseline program needs, are pending the outcome of the baseline program reassessment expected to be completed in the Spring and Summer of FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION CREW RETURN VEHICLE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
X-38/Crew Return Vehicle	75,000	89,802	

* FY 2001-2002 funding is currently under review and allocations to X-38/Crew Return Vehicle (CRV) will be determined as part of the program assessments. CRV production (Phase 2) was funded in the SAT account in the FY 2001 budget runout. Those funds were redirected to Space Station in the HSF account to address cost growth on the program.

PROGRAM GOALS

The safety of the crew for the International Space Station is of critical importance. The Russian Soyuz vehicle provides a capability to return the crew from orbit if needed for life threatening emergencies that may arise on orbit. Continued sole reliance on a single Soyuz capability limits the crew size for the ISS and poses operational and programmatic impacts. Each Soyuz can only transport a crew of three and has to be changed out after about six months on orbit. A more capable crew return vehicle that overcomes the limitations of the Soyuz is the most desirable long term approach for ensuring crew safety. A goal of the Crew Return Vehicle (CRV) project is to leverage the technologies, processes, test results, and designs developed in the preliminary technology development work carried out in the X-38 project and related contractor studies of a CRV.

The Crew Return Vehicle (CRV) project will initiate work towards an independent U.S. crew return capability for the ISS. The CRV would accommodate safe return for up to seven crew under the following scenarios:

- Crew member(s) ill or injured while the space shuttle orbiter is not at the station
- Catastrophic failure of the station that makes it unable to support life and the space shuttle orbiter is not at the station or is unable to reach the station in the required time
- Problem with the space shuttle that makes it unavailable to re-supply the station or change-out crew in a required timeframe

STRATEGY FOR ACHIEVING GOALS

NASA has funded the X-38 project to reduce the risk of developing a CRV. The X-38 design has a strong foundation from the lifting body research and technology developments carried out since the 1960's. The plan to transition from X-38 research and development to CRV design and development is comprised of the following phases:

- Phase 0 - An unfunded observation period in which contractors interact with the X-38 project team. This effort began 20 July 1998 and is now complete. Five companies participated in this phase which was performed with X-38 Advanced Projects funding.
- Phase 1a – Selected contractor(s) will perform delta design tasks to convert the X-38 design into an operational CRV design and participate in the X-38 flight test program as a part of CRV verification and validation. Phase 1a is fixed cost, runs for about 12 months and includes tasks and deliverables up through Preliminary Design Review and Interim Design Review.
- Phase 1b – After Phase 1a, one contractor will continue the CRV design development and test program support up through the X-38 vehicle 201 space flight test and CRV Critical Design Review. This phase will also be fixed cost and will last about 20 months.
- Phase 2a – This phase of CRV production is a cost-plus-incentive-fee contract for delivery of the first two operational CRVs. It is expected to last for about 24 months.
- Phase 2b – This phase is a fixed-cost contract for delivery of the third and fourth operational CRVs and is slated to run about 27 months.

These phases will include three primary tasks:

- Perform delta design tasks necessary to convert the X-38 design into an operational CRV design, and perform necessary system integration internally and with STS and ISS.
- Support atmospheric and space flight tests of X-38 prototype vehicles as part of CRV validation.
- Perform production of the CRV operational vehicles.

In the FY 2001 budget runout, CRV Phase 2 funds for development and production were included in the SAT appropriation, to better integrate CRV activities with broader space transportation architecture activities and goals in the Space Launch initiative. As a result of cost growth on the ISS program, these funds were allocated back to the Space Station HSF budget to address this growth. No funding for Phase 2 activities are identified in this budget. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete, like the CRV, will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

The recent program reassessment indicating significant ISS cost growth has led to the redirection of Phase 2 funding previously planned in the SAT appropriation, to mitigate ISS funding requirements. Further review may also adjust Phase 1 plans.

SCHEDULE & OUTPUTS (X-38 PATH) - The project schedules will be reviewed during the restructuring activity and adjusted as part of the program reassessment.

Start Contractor Observation period Plan: July 1998 Revised: Completed	Beginning of period in which potential contractors observe X-38 Program flight demonstration test and development activity.

CRV Request For Proposal release for Phase 1a Plan: March 1999 Actual: November 1999	Release RFP for a funded period in which two contractors will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing.
Phase 1a Start Plan: October 1999 Revised: 4th Qtr FY 2000 Revised: June 2001	Contractor(s) will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing. Matures CRV through PDR and IDR.
Phase 1b Start (new to plan) Plan: June 2002 Revised: Under review	Single contractor matures CRV through CDR. Supports X-38 space flight test, data analysis and design impacts to CRV in support of CRV verification and validation.
Phase 2 CRV development contract Plan: December 2000 Revised: June 2002 Revised: TBD	Award of development contract for operational CRVs. To be split into a cost- plus contract for CRVs 1&2 and fixed-cost contract for CRVs 3&4 (currently no funding is identified for Phase 2)

ACCOMPLISHMENTS AND PLANS

FY 2000

In FY 2000, the project completed the fifth successful X-38 atmospheric free flight test in which the flight control system was validated. According to the requirements of the independent assessment team, a full scale 7500 square foot parafoil was manufactured and successfully flown twice in platform drop tests. X-38 vehicle 131 was modified to match the operational body shape and delivered to JSC for outfitting in preparation for an early FY 2001 flight. The RFP for Phase 1(a) was issued to industry, proposals were received and reviewed, and the source evaluation board process was largely completed. An additional 40 maturity gate actions were completed in FY 2000, bringing the total to 97 complete out of 110, securing the approval of NASA's Program Management Council to proceed on to the award of preliminary CRV design contract Phase 1(a). The coupled loads analysis on the Deorbit Propulsion Stage was also completed.

FY 2001

X-38 and CRV plans will be defined as part of the program reassessment.

The X-38 project continued with atmospheric vehicle and parafoil flight testing, and the space flight vehicle build as the prototype for the ISS Crew Return Vehicle (CRV). X-38 flight testing has successfully demonstrated numerous technologies needed for the operational CRV. Among the more important of these is flight of the operational body shape and full operational scale parafoil, advanced flight control software, electro-mechanical actuators and laser activated pyrotechnics. The first of two 80% scale atmospheric test vehicles, vehicle 131R, was modified to match the expected CRV production vehicle body shape and successfully completed its first free flight test in November of 2000. Free flight tests progressively match larger portions of the CRV operational reentry flight profiles to enhance performance validation as X-38 testing plays an important role in the overall CRV flight certification plan. Two more atmospheric flights are planned for this year.

In addition to the flight test progress, several important X-38/CRV reviews were successfully completed. The Shuttle Payload Safety Review, the X-38 Entry Safety Review, the KSC Ground Safety Review, an Aerodynamics Peer Review and a Landing Site review were all completed with several minor issues cited but no significant issues identified.

Structural design changes to the X-38 Deorbit Propulsion Stage (DPS) were completed and all propulsion components were mounted to the main deck. The flight unit DPS is on schedule for delivery to NASA in spring 2001 in preparation for the vehicle 201 space reentry flight test tentatively scheduled for early 2003. The vehicle 201 build and verification matured to 70-80% completion.

FY 2002

X-38 and CRV plans will be defined as part of the program reassessment.

In addition to continuing the X-38 prototyping work mentioned above, the following provides an indication of the design and development work which would be conducted, using both civil servants and contractors.

CRV Vehicle Subsystems

NASA Tasks
Avionics work would include continued development of the CRV inertial guidance system (SIGI – System of Interactive Guidance and Information); avionics instrumentation; radiation-hardened computer system network elements; operating and flight system software; and communication system signal processors. Flight dynamics work would include simulation-based development and verification of the CRV flight controls. Mechanisms work would include delivery of electro-mechanical actuators (EMAs) and laser pyros, and EMA testing. Parafoil work would continue with testing, new parafoil procurements, and integrated structural dynamic modeling. Thermal Protection System component procurement would also continue.

Phase 1a and 1b Contractor Tasks
Contractor tasks would be focussed on designs of CRV subsystems including avionics computers, networks and data busses; instrumentation and sensors; electrical power system; communications system; engineering support; laser altimeter; data recorder; avionics testbed; human computer interface; flight software; and interconnect wiring and connectors. Mechanisms work will be performed on the berthing/docking design and fin mechanisms. Manufacturing work will continue on the berthing/docking module engineering development unit; metallic structural parts materials and machining; composite structural parts materials and manufacturing; and tooling. Structures work would begin on structural, hatch, window and couch design.

Systems Engineering and Operations

Safety, Reliability, and Quality Assurance, and Systems Engineering and Integration work would be performed as NASA primary tasks supported by the Phase 1a contractor(s).

Operations tasks include analyses of CRV separation (from Space Station) dynamics, continuing development of landing site and site selection requirements, and development of crew displays and controls requirements. Mission operations tasks include Mission Control Center and facility design requirements, modeling, and development of flight and ground procedures and flight rules. Logistics and maintenance tasks would focus on development of a spares program. Kennedy Space Center tasks include development of launch support and logistics flight operations requirements.